DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. XI. No. 122. FEBRUARY, 1930. PRICE 1s. NET

THE EGYPTIAN GODDESS THOUERIS
(Ancient Glass Figure. See page 61.)

CHIEF CONTENTS.

	Pages
Editorial Notes	35
The End of an Empire	37
The Secret of the Canyon ...	42
Science Museum's Progress ...	46
Birmingham University To-day	47
A Naturalist in Basutoland ...	52
Ospreys in Scotland	56
New Motor-Car Research ...	58
Glassware Problems	61
Bird Life in the Arctic	64
Book Reviews	65

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Editorial Notes.

The Royal Commission on National Museums and Galleries will go down to history for the speed and promptness with which its task has been completed. There are still cases in memory to support the political maxim that the best way to shelve a question is to appoint a Royal Commission, but it is entirely contradicted by the inquiry over which Lord d'Abernon has presided since July, 1927. The Interim Report issued in September, 1928, was widely welcomed for its clear statement of the problems involved. Exactly a year later Part I of the Final Report appeared, and has now been followed by Part II. The wide scope of the Commission has not precluded the closest attention to detail. As we pointed out in the earlier stages, it was evident that even to obtain a knowledge of the varied contents and the working of these institutions was a formidable task. There were local conditions to be considered, and no fewer than twenty institutions came within the terms of reference. Yet every section of the Report is notable for the breadth of purpose which has clearly inspired its conclusions. We print some extracts about the Science Museum on another page. As regards the British Museum two administrative changes are recommended. The present Standing Committee supervises not only the literary, historical and artistic collections at Bloomsbury, but the collections of natural history at South Kensington. In the opinion of the Commission the burden of responsibility thrown upon this committee has become too great and the future interests of both departments would be advanced if two bodies were created, one constituted with special regard to the humanistic collections and the other to natural history. As a corollary of this change, it is suggested that the Director of the Natural History Museum should be made wholly responsible for the care and custody of the collections housed therein. On the question of the Botanical Department of the museum and its relation to the Royal Botanic Gardens at Kew the Report is not so definite. The view is indicated that a combination of the two institutions represents the ideal to be aimed at, but there are difficulties which make any hasty decision inadvisable. At present, investigators have often to visit both places, not always a convenient procedure; on the other hand, each herbarium is an indispensable wheel in the machinery of the institution to which it is attached.

* * * * *

In view of the discussions on Education for Industry which have filled the newspapers in recent weeks, our article this month on Birmingham University appears at an opportune moment. Not only can Birmingham claim to be the first provincial university created in the capital of a large industrial area; it was the first university in the country to create a Faculty of Commerce. The plan has been to train men and women for business through a course of university studies, as distinct from preparing them specially in economics or technology. These latter studies are provided for in other departments, such as engineering, metallurgy and mining. The experience of Birmingham in these matters therefore demands the closest attention. "Our aim," the Vice-Chancellor writes, "is like that of the good bridge player, to develop strength in our leading suits and to discard from the weak ones. In industrial technology we readily leave the textiles to Lancashire, wool to Yorkshire, marine engineering to Newcastle, Glasgow and Belfast. But, above all, we believe that in industry it is pure science that matters, and that mathematics, physics and chemistry are the basis of university and industrial efficiency and advance.

The best service a university can render to business is to train the mind, for the mind's sake, and develop science for science's sake."

* * * * *

Sir Richard Gregory prefaced a lecture last month to the Royal Meteorological Society with some interesting historical observations. His subject was "Weather Cycles and Weather Recurrences." When Joseph interpreted Pharaoh's dream of seven fat kine and seven lean kine as signifying seven years of plenty and seven of famine, his prediction was based upon a weather cycle or period of about fourteen years. Though the periodicity could not have been very highly developed, it was sufficiently well-marked to influence the general character of the seasons. The predictions made by Elijah and Elisha may have been founded upon knowledge of this kind also. The extraordinary weather of the year 1929—frosts, droughts, floods and gales—gives renewed interest to the question whether these abnormal phenomena return in regular cycles or whether their occurrence is irregular. Innumerable weather cycles have been described, of which the best known are the Brückner cycle of about thirty-five years and the sunspot cycle of eleven years. In the rainfall of the British Isles a fifty year cycle is far more evident that the Brückner cycle, and gave us, for example, wet periods in the 1870's and the 1920's. Other cycles include those having a length from five or six days to a month. A possible seven-day cycle has been discovered in the manufacturing town of Rochdale, where the rainfall on Sunday, when the air is comparatively clean, is on the average less than that on the other days of the week when the air is smoky from the factory chimneys. A more general cycle of five or six days probably exists over the greater part of the northern hemisphere, but the general conclusion is that neither cycles nor recurrences are at present of any value in forecasting coming weather for any particular year, month or day.

* * * * *

The legend of Robert Bruce has assured for the spider a permanent place in history. Now it seems that this insect can claim its share in modern scientific discovery. At the Canadian Government survey offices in Ottawa, many yards of spider thread are used every year in overhauling survey equipment. The thread is placed in the optical system of the telescope as an aid in sighting upon definite objects. The spider thread is stretched across a metal diaphragm or ring, which is supplied by instrument makers and is carried as a spare part by the surveyor in the field. Occasionally, however, the surveyor may be under the necessity of replacing a broken strand by one obtained directly from a spider itself. A spider is caught and induced to spin a few strands which are made to adhere to the metal ring. The strand should be a single one, free from dust, and slightly stretched so as not to sag when placed in the ring. The body of a spider contains sufficient fluid to make a considerable length of thread. The secreted fluid hardens on exposure to the air, and makes a strand that is stronger than silk of the same thickness. The manner in which the spider is induced to spin its thread and the methods used by the surveyor to fix the strand to the ring are extremely interesting. The operation is always a delicate one requiring a fine sense of touch and much skill on the part of the operator.

* * * * *

Some days ago we saw an advance display of "Stampede," a new film taken by Major Court Treatt among the Sudanese tribes and produced by Pro Patria Films, Ltd. "Stampede" is notable for the fact that no professional actors were employed; the cast numbered eight thousand African natives. Hundreds of wild animals play a part in the story, which is perhaps most remarkable as showing an entire tribe "on the trek." The spectator is given a vivid idea of how the Children of Israel must have appeared in the desert thousands of years before. Other pictures include the greatest forest fire yet filmed—a terrifying but magnificent spectacle that should alone ensure the success of the production.

* * * * *

Mr. S. R. K. Glanville's lectures at the Royal Institution, which concluded on 9th January, were notable from several points of view. "How they did things in Ancient Egypt" was a title that of itself promised some interesting hours to those who were wise enough to attend the meetings. At the same time, the choice of an archaeological subject for the Christmas Lectures marked a break with Faraday's tradition now more than a century old. There is some sort of precedent in the fact that Thomas Young, who held the Royal Institution's Professorship in Natural Philosophy at the beginning of the last century, is also honoured as the chief of the earliest English decipherers of hieroglyphic writing. But no apology was required, for the days are fortunately past when the archaeologist was regarded merely as a digger for buried treasure. In referring to the building of the great Pyramid and other monuments, Mr. Glanville said that the recent work of Engelbach on the unfinished obelisk in the quarry at Assuan had finally revealed the main processes.

The End of an Empire.

By D. Talbot Rice, M.A., B.Sc.

For nearly five hundred years the Greek colony established in the region of Trebizond by the Comnene Emperors maintained its national independence, until in 1922 it was "exchanged" with Turkey. Having recently visited the region, the writer urges exploration before its beautiful buildings are completely ruined.

The winter in England had been a hard one and the spring in central Europe none too pleasant, so the beauty of a warm Turkish May came as a welcome surprise. We determined to take full advantage of it, and to see as much of the interior of Turkey as possible on our way to Trebizond, and we therefore set out by car from Angora. Our intention was to go all the way to Trebizond in this way and to visit the interesting monasteries in the hinterland of the city before visiting the town itself. But the state of the roads was such that our original intention had to be abandoned, and we finally reached our goal by sea. We saw much of the interior, however, and by the end of our journey we were fairly familiar with the region which was known to the ancient Greeks as the Pontus, a rather distant and wild place, but nevertheless accessable and familiar to travellers at least. It was probably much the same to the ancient Greeks as the Balkans were to Western Europe about eighty years ago.

The First Emperor.

With the end of the classical regime the region fell into the hands of the Byzantines. It was for a considerable time directly dependent on the capital at Constantinople, but by the eighth century Mohammedanism had begun to affect the whole of the Nearer East and Asia Minor was already falling before the advance of the Turks from the north-east and of the Arabs from the south. Little by little the Empire fell away and little by little the power of the rulers at Constantinople decreased, until, in 1204, the city itself fell, not to the Moslems, but before the hosts of those who had come to protect western Europe from the Infidel. A Latin empire was established at Constantinople, and the Greek royal family fled the city, to establish minor kingdoms where they were able. One of these, a prince of the royal blood, founded at Nicaea an empire whose ruler was at a future date to reconquer Constantinople and re-establish there the Byzantine power, while another, less famous perhaps, but in many ways no less enterprising, was the first of a line of emperors at Trebizond which was to last for longer than any other in the whole of Byzantine history, and who were to defy the Turks longer even than the rulers of Constantinople, then counted the most formidable city in the world.

The founder of this line was Alexios I Comnenus, nephew of Tamara, the Queen of Georgia, who was the most renowned and most powerful ruler in the eastern Black Sea region. Under her Georgia was an important state, both politically and artistically, and for centuries afterwards legends recalling her powerful rule and determined character were circulated. She is familiar even to-day, though in a more romantic sense, to frequenters of the Russian Ballet in western Europe. Through her aid, and to some extent through his own enterprise, Alexios succeeded in establishing himself at Trebizond, where he was welcomed by the whole population as emperor. From the Latins in the west there was not much to fear, for they were already well occupied, and Nicaea and Salonika were far more formidable rivals than the distant Trebizond. Continual trouble was to be experienced from the other direction, however, for the power and energy of the Moslems of western Asia was increasing daily, and the Seljuks, the Mongols, and at a later date, most important of all, the Ottomans, had to be dealt with.

Royal Beauty.

Wars were thus fairly frequent in the history of the little Empire, but it was more by strategy than by force of arms that she succeeded in maintaining a secure position in the midst of such powerful enemies. Luckily for Trebizond the chief of these, the Turks, Ottoman and Seljuk, and the Mongols, were always opposed to one another, so that the Christians were able to side with each in turn, and by tactful strategy to play off the one against the other. But perhaps of greater import than the brilliance of her statesmen was the beauty of the princesses of the royal house. On more than one occasion immunity from attack or even military assistance against an enemy was procured by marrying the daughters to right and left, to Moslem and Christian alike.

It was thus that the eastern Comnenes defied all

enemies for 259 years, without any continued help from outside. Westerners, in fact, in the form of Genoese and Venetian traders, were perhaps more of a trial than a support, and with the former, especially, the Emperor was as often as not in actual conflict. But in 1461 the gallant little outpost of orthodox Christianity fell to the all powerful Moslem. The Greeks were turned out of the central and walled portion of the town, and their churches there were converted to the worship of Islam. But in the country around the city they remained unmolested, and we even read that the Sultan Selim granted a fireman and made certain gifts to the monastery of Sumela. The Greek minority was actually singularly free, churches were built, monasteries flourished, and the general tenor of life was unchanged.

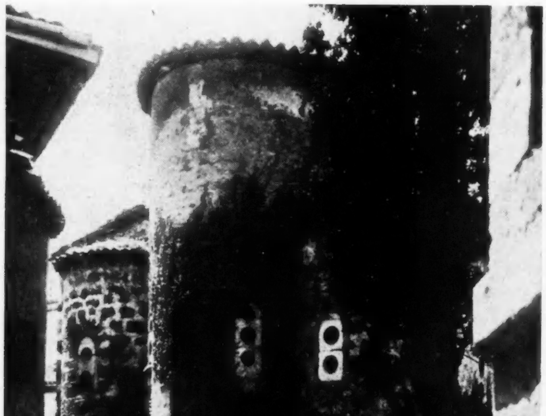
A Million Refugees.

With the Great War a new state of affairs arose, the long buried differences of religion came to the fore, and the Turks and Greeks entered into a bloody conflict, which was to be responsible for numerous atrocities and uncalled for acts of cruelty on either side. Finally a scheme was devised, according to which Greeks within Turkey were exchanged for Moslems living in Greece. Of the three million Greeks who had inhabited the Pontic region only some million and a half ever reached Greece, as refugees, destitute and suffering. The rest succumbed to the rigours of the climate, to famine and to disease, which at this time raged over the whole Near East. Their houses were left, to be looted and destroyed, their churches derelict, and their property a prey to the numerous bands of marauders, Bolshevik, Armenian, and Turk, who swarmed over the unsettled country.

It was to see what remained of these churches, some of which were reputed to be as fine as any that Byzantium left to the world, that we undertook our journey to Trebizond, and it was thanks to the generosity of Mr. Rudolph Messel that we were able to make it, and to record all that survives by means of photographs, plans, and descriptions.

Beset though they were by political troubles, the activities of the Comnenes in the sphere of art were of a widespread nature. In spite of wars, and continual draws on the treasury, they found enough money to devote to the building and endowment of religious institutions and churches, as well as to attend to the walls and the fortifications of the city. Most liberal among the emperors in this respect was Alexios III, who endowed the famous monastery of Sumela, hidden away up in the mountains some sixty miles inland of his capital. Outside the empire his grants were no less generous, and it is to him that the monastery of Dionysiou on Mount Athos owes its being. To both monasteries he granted golden bullae, elaborately painted and decorated. That of Dionysiou is still preserved, but kept in scrupulous seclusion by the monks. That of Sumela was shown to visitors before the war, but now it has disappeared—one hopes that it may have reached some collection in America or western Europe, by way of the bazaars of Constantinople. One hopes, too, that certain relics and an icon supposed to have been painted by Saint Luke, which were also prized by the monks of Sumela, have gone the same way.

The monastery itself, which clings to the face of a huge rock, some seven hundred feet above a rushing torrent in the valley below, has been, anyhow, most efficiently looted. Floors have been torn up, ceilings torn down, and even the tiles thrown from the roofs. Only the frescoes which covered the walls of the rock-cut church, both outside and in, remain, but they, too, will soon go the way that the rest of the monastery is going, and in a few years there will



THE CHURCH OF ST. ANNE.

Until 1922 this church, the oldest in Trebizond, was used for services. Now it is inhabited by a family of gipsies, and the smoke of their fire blackens the frescoes.

be little left to interest the traveller except bare walls and mouldering plaster.

Though Sumela is the most famous of the monasteries, there are others which are no less astounding in the inaccessability of their positions, or no less attractive as regards the architecture of their churches or the beauties of their frescoes and overhanging galleries. The monastery of Kushtul, for instance, stands on the summit of a conical peak with a deep pine clad valley to one side, and a mountain towering to a height of some four thousand feet on the other. And at Ayana monastery the dwelling rooms, which date from the sixteenth century or even earlier, are finer than the best that are to be found on Mount Athos. There are about twenty such monasteries within a radius of sixty miles of Trebizond, most of them to be reached only by the most difficult of mountain paths, so that few of them have ever been visited by travellers from the West. But even less well known are the churches, of which there are said to be some three thousand in the area. Nearly every one stands on the top of a secluded hill, as often as not some six or seven hundred feet above the valleys which run between the hills like the cuts in a jig-saw puzzle.

Many of these churches are new and without particular interest, but here and there a small chapel stands out as a monument equal to those of Greece and the Balkans. But they are deserted, or sometimes are suffering an even worse fate at the hands of local peasants, who use them as stables or camping places. The roofs are beginning to fall, and the delicate paint and plaster of the frescoes will not withstand many more winters when they are fully exposed to the damp. One wishes that a few of them at least could be transported bodily to Europe while there still remains something worth transporting.

The Moslem Conquest.

Within the town itself the churches have fared somewhat better, for the larger and more important ones were turned into mosques at the time of the Turkish conquest (1461). They have thus been kept in repair at least. Of those that exist to-day the most conspicuous is the mosque of Orta Hissar, which was originally the cathedral church, dedicated to the "Golden Haired Virgin," Panaghia Chrysokephalos. In some ways it was luckier than the other churches, for the few additions that have been made from time to time have done little to obscure or alter the original plan of the building. It is still a church rather than a mosque, and the visitor cannot fail to see how fine it must have been in its original state, with its three aisles, each terminating to the east in a semi-circular

THE SOUTH DOOR OF ST. SOPHIA.

The frieze above the door, depicting scenes from the Old Testament, is the most interesting work of its type that exists. The church is rapidly falling into ruin.

apse, adorned with frescoes or mosaics. The decorative mosaic work of the style known as "opus Alexandrinae" which covered the walls of the central apse are still preserved, though in part they are covered with whitewash. The walls of the church itself were covered with frescoes from floor to ceiling, and the body was doubtless filled with numerous minor works of art. One can imagine the interior as it was by conjuring up memories of churches seen in Greece or on Mount Athos; overfull and overornate perhaps, but yet possessed of a mysterious appeal. As a mosque, however, the effect is very different. The gay frescoes are plastered over, the walls are white and bare, and the centre of the church is empty except for the rugs which cover the floor and afford the only splash of colour in the whole interior. The rugs are often very fine, but the enthusiastic Byzantinist prefers the frescoes, even if the accompanying decoration is too elaborate, and he is not satisfied with the occasional glimpses that are offered to him in places where the Moslem plaster has fallen away. The colours, but none of the scenes, were discernable here and there,

and it remains for some future explorer to uncover the whole. Someday, perhaps, researches in the cause of art will no longer be hampered by the exigencies of a narrow religious prejudice.

Whitewashed Frescoes.

Outside the citadel a second mosque, that called the Yeni Djouma, also dates from Byzantine times. In plan it is more simple than the cathedral, but originally it must have been almost as fine a building. Now, newly whitewashed and painted, it awakens feelings of enthusiasm for the energy of its frequenters, an energy which is all too rare in Turkey, where mosques and houses are built but hardly ever repaired. But as Byzantinists we wished that the activities of the plasterers and whitewashers had been a little less violent, for here no traces of the frescoes that originally covered the walls are to be observed. In one corner, however, a stone lintel decorated with an ornamental frieze, remains as a witness of the orthodox love of elaborate and overcrowded interior decoration.

More satisfactory for the lover of the Byzantine is the church of Saint Sophia, which stands on a promontory above the sea, some two miles to the west of the town. Originally there was a monastery here, but of the buildings of this nothing remains except the bell tower, which stands close to the church. The two lower stories are of Byzantine, the upper one apparently of later date, for the church was not turned into a mosque until some years after the Turkish conquest. As the region around it is but sparsely inhabited by Moslems, few additions or alterations were made, and as the building stands at present, there are few traces of its adoption by Islam. The church has three semicircular apses at the east end, an exonarthex and porch at the west, and large porch-like transepts to north and south. The central area is roofed by a wide dome. The floor below this must at one time have been a marvel of the type of mosaic work known as "opus Alexandrinae," but it is now, alas, in a very poor state. Enough remains to show what an elaborate and delicate construction the floor was in Byzantine times, when it must have been as fine, if not finer than the floor of the church of Saint John of Studion at Constantinople. The walls at Saint Sophia, too, must have been equally impressive, for the traces of frescoes that can now be discerned show that the paintings were of a very high order. With the introduction of Islam these were, of course, painted over, but in 1916, when the Russian troops captured Trebizond, an archaeologist was at once sent for to undertake the preservation of the ancient monuments in the city. Uspenski, formerly director of the Russian school of archaeology at Constantinople, was chosen, and one of the first pieces of work that he undertook was a preliminary cleaning of the frescoes of Saint Sophia. The work was never finished, but the apse itself and three scenes on its northern wall which were cleaned, serve to show the excellence of the work, which we hope will one day be disclosed in entirety for the benefit of all students of Christian art.

To-day, however, some uncovered frescoes still remain elsewhere which were never plastered over by the Turks. They will, unfortunately, all too soon disappear, for they are situated in buildings no longer cared for now that the Christian element of the population has departed. The first series of these decorate a small chapel on the first floor of the bell tower, close to Saint Sophia. The paintings are dated by an inscription to the later years of the fourteenth century, and are thus of considerable interest in the history of Byzantine painting. As time goes on, the importance of the Byzantine in the study of Christian art in general is coming to be realized more and more, and in a few decades it seems that lovers and students of the subject will make pilgrimage to Mistra, Mount Athos, or Trebizond, just as they do now to Assisi or Padua. At Trebizond there are frescoes in the mosques now covered, which they will doubtless be able to see. But of the others now visible, so little care is taken that in a few years practically all traces will be destroyed. In a Moslem country there is perhaps ample excuse, but at Mistra and on Athos one feels that more might be done. More durable are the fine reliefs in stone over the south door of Saint Sophia, which have been described by every traveller since the time of Texier.

A Gipsy Encampment.

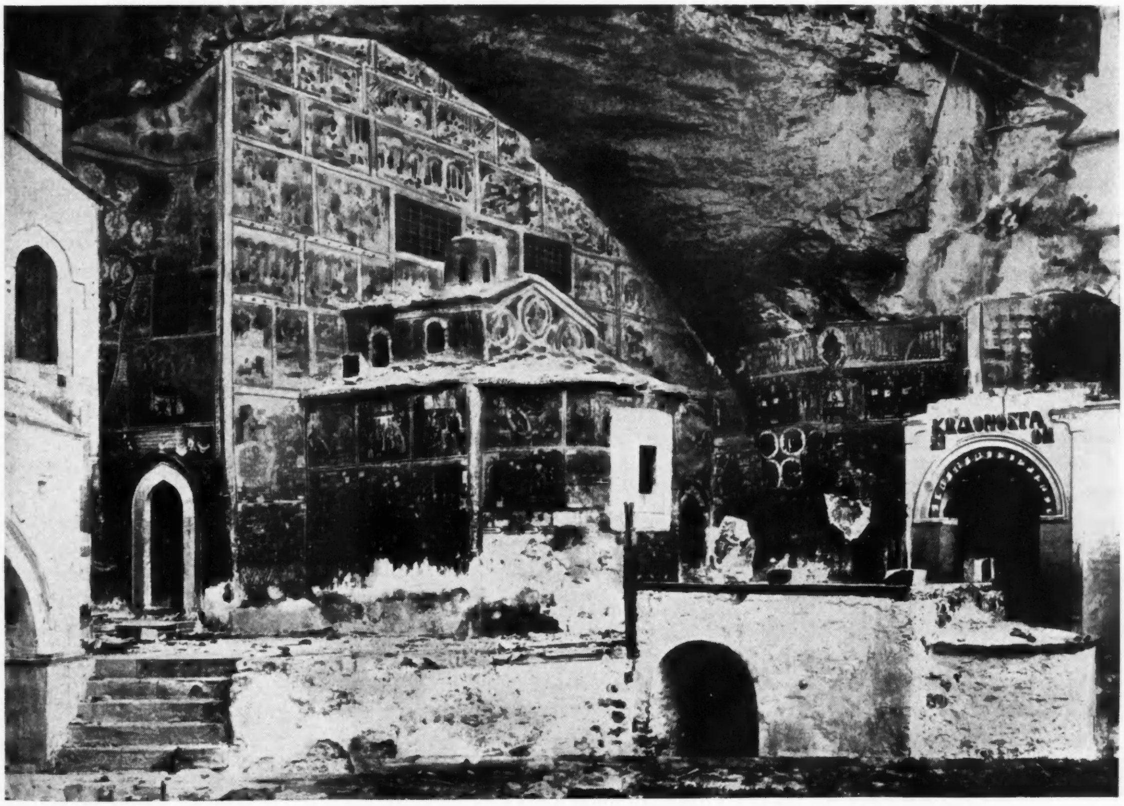
From Saint Sophia the architect turns eastwards towards the town itself, where several old churches claim his close attention. Saint Philip, a domed structure of the thirteenth century, is now a mosque, but its original plan has been little affected. Equally unaltered as regards plan is the small church known as Nakip Djami, the Christian name of which has long been forgotten. It is of a different plan, rectangular, with three aisles and three semicircular apses, but no dome, and like the church of Saint Anne, belongs to a date earlier than those of the domed structures. Saint Anne, however, is a finer example of the style and is in a better state of preservation, for it was used as a church until the departure of the Greeks in 1923. Below the church is a crypt, now inaccessable. Above, the central aisle stands up to nearly double

the height of the side ones. To the west and south were doors, but the former was blocked up, probably during Byzantine times. Above the latter a large classical relief, bearing an inscription, has been built in, but it is hard to distinguish the subject.

Here, too, the artist should go, for within the church there are frescoes. Until 1922 these were well cared for, though too zealous overpainting may have somewhat obscured the earliest work, for the building had been in continual use as a church since the day of its construction. But with the exchange of populations it fell into disuse, to be seized upon as a dwelling by a family of peasants, the greasy smoke of whose fires has now almost entirely obscured the paintings.

The church of the Theokepastos monastery, once the burial place of kings, and, until the war, the home of a happy smiling body of nuns, has fared equally badly, but it matters little, for the convent has now been sold for the value of the stone of which it is built, and a contractor has already started his work of destruction. If the church, the only really old part of the monastery, is spared, it will be because it is cut in the rock, and therefore cannot be pulled down. Its only use is as the stable for cattle, which it has already become. How are the mighty fallen ! For five centuries the cave was a convent church, endowed and adorned by emperors, for further centuries it was the place of worship, perhaps even of martyrdom of the various hermits who were responsible for the introduction of Christianity to Trebizond, and before that the cave was one of the chief temples of the Pagan city, the shrine of Apollo-Mithras, the peculiar god of Trebizond.

The frescoes of three rock-cut chapels near-by show some of the finest work in Trebizond. The artist should inspect them, but it is only the most sincere of enthusiasts who will pursue the search further, for the minor buildings of Byzantine times and even more, the examples of contemporary or later art that they contained, have fared even worse than the major ones. The Empire of Trebizond, conquered in 1461, but extant in a vague way until 1922, has now truly come to an end.



THE CHURCH OF THE MONASTERY OF SUMELA, A HUGE CAVE HEWN OUT OF THE ROCK.
In the centre of the picture is seen the small *bema* or choir with rounded apse, which faces east. The whole church is gaily decorated with frescoes.

The Secret of the Yellowstone Canyon.

By O. T. Jones, M.A., D.Sc., F.R.S.

Professor of Geology, University of Manchester.

The discoveries of an expedition to Yellowstone National Park, in which the writer took part recently, throw an entirely new light on the history of the "Grand Canyon." The secret of this canyon that has fascinated geologists and travellers for many years is now believed to be solved.

THE Rocky Mountains of America are traversed by many remarkable canyons, but in beauty both of form and colouring none of them can vie with the famous "Grand Canyon" through which the Yellowstone River flows on its way northward from the Yellowstone Lake to join the Missouri. In addition, this canyon can claim a geological history as wonderful as that of any canyon in the world. The purpose of this article is to give in brief compass its story, which has had to be largely revised owing to recent discoveries.

The Rocky Mountain belt is of great geological as well as scenic interest; and with great foresight a tract about equal in size to the combined areas of Cumberland and Lancashire was set aside as a National Park for the enjoyment not only of citizens of the United States of America, but of all others who have the good fortune to be able to visit and explore it. I was privileged to visit this region in 1928, as the guest of the Summer School of Geology and Natural Resources, which was founded by Professor Richard Field, of the University of Princeton, who also directed the tour. During our stay in the Park we were led to re-examine the history of the canyon, in the light of certain phenomena, some of which appear to have been observed previously, but their significance had been generally overlooked. The tentative conclusions to which we came as a result of our examination were so much at variance with the views hitherto expressed in regard to the history of the canyon that Professor Field and the writer decided to return to the Park to examine further into some of the evidence upon which our deductions were based.

The Yellowstone National Park is situated in the north-west corner of the State of Wyoming, where it borders on Montana and Idaho, and not far within the eastern border of the Rocky Mountain belt. This belt was affected by great earth movements towards the close of the Mesozoic period, and following on these movements intense volcanic eruptions from numerous centres gave rise to accumulations of thousands of feet of volcanic debris, or breccia having the general composition of the rocks known as andesites. Lavas mainly of andesites or basalts flowed over the surface at intervals. On Specimen Ridge, not far from the Yellowstone Canyon, we have evidence of great forests growing on the surface being overwhelmed by the accumulations of fresh volcanic material, and later re-establishing themselves only to be buried anew. The relics of these forests are now preserved in a great cliff of andesitic breccia, in which successive layers of fossil or silicified trees are plainly visible.

There followed a prolonged pause in the volcanic activity, and the volcanic rocks were subjected to active erosion, in the course of which they were deeply sculptured into hills and valleys. When activity was renewed, great sheets of obsidian and rhyolite flowed into the valleys and levelled up the country. At the present time the earlier andesitic breccias and the older rocks on which they rest form a discontinuous mountain rim round the Park, rising in places to about 11,000 feet. The later flows of rhyolite and obsidian form a high level plain known as the Park Plateau, in the central region of the Park, which stands at a general elevation of about 8,000 feet.

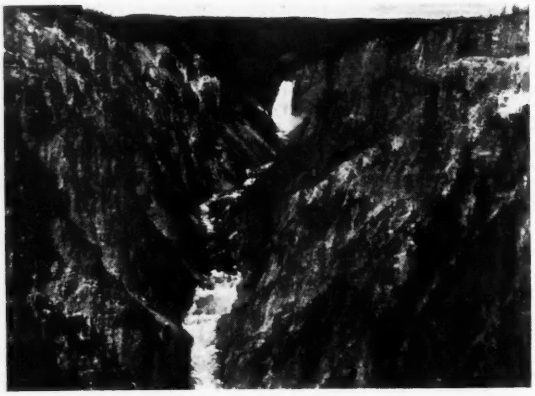


FIG. 1.
THE CANYON BELOW THE FALLS.
In places the canyon is here nearly 1,000 feet deep. Owing to decomposition its steep, bare walls have taken on a most remarkable array of colours.

The principal valleys which drain the Park have been carved in these varied volcanic rocks.

Fig. 2.
THE RIM OF THE SECOND CANYON, FORMED OF BASALT.
The basalt rim (which looks like a fence in this photograph) is divided by a uniform system of jointing into close-set, vertical columns.

As we shall see later, there were renewed eruptions of basalts and other rocks, mainly in the northern region of the Park and outside its limits to the north. These later eruptions exercised a profound influence on the history of the canyon. Numerous hot springs and geysers which are still active in various portions of the Park testify that volcanic activity has not entirely passed away. The hot water and gases given off in these hot springs and geysers have decomposed the rocks through which they passed to such an extent that they are more easily eroded than the surrounding tracts of unaffected rocks. Most of the geysers and hot springs now form low-lying tracts or "basins" in the Park Plateau.

For our purpose the Yellowstone River may be regarded as having its origin in the Yellowstone Lake. Below the lake the river flows for several miles through the Hayden Valley, a very wide valley cumbered by great mounds of glacial deposits. This valley stands in striking contrast to the great canyon which begins at the falls in the neighbourhood of Canyon Camp (one of the tourist camps of the Park). There are two falls, the upper fall being 109 feet and the lower one 308 feet. Below the lower fall, the canyon in places is nearly 1,000 feet deep, and its steep, bare walls are formed of obsidian, which is in many places decomposed to a white rock like china clay by the agency of thermal waters (Fig. 1). By reason of this decomposition the rocks have taken on a most remarkable array of colours. Some are white or cream coloured; others are a brilliant maroon; and yet others exhibit various tints of green. The form of the canyon, the extraordinarily vivid colouring of its walls, with the raging torrent at their base, together produce an unforgettable effect.

The canyon widens gradually down stream, and its walls are less steep, but about twenty-four miles below the falls the river suddenly plunges into an extremely narrow canyon, with almost vertical walls, eroded in this case through the andesitic breccias which have been carved into remarkable needle-like pinnacles. This is known as the second canyon, in contra-distinction with the main canyon above this point.

The rim of this canyon, on both sides, is formed by a flow of basalt divided by a uniform system of jointing into close-set, vertical columns (Fig. 2). Several tributaries, generally known as creeks, enter the canyon from either side; these fall precipitously into the Yellowstone. Below the second canyon, however, an important tributary, the Lamar River, flows in a valley of very different form from that of the higher tributaries. The history of the Lamar Valley is intimately related to that of the Yellowstone Canyon. The difference in form between one part of the canyon and another furnishes the clues to its history, up to a point.

For the benefit of the general reader, the normal mode of development of a river valley may be briefly stated.

Most valleys have been eroded by the river which occupies them. Starting on a surface at least as high as, or higher than the brows of the valley, the river began by carving for itself a narrow trench-like channel. As the trench became deepened, the slopes gradually receded by weathering. Near the mouth of a valley, a channel cannot be eroded sensibly, if at all, below sea-level, but when vertical erosion ceases the river is able by lateral or side erosion to enlarge its valley to a considerable width. Concurrently with

this widening, the slopes on each side recede, and with the passage of time their inclination becomes progressively less, owing to the continuous operation of weathering. In time, a condition is reached when a continuous slope is established along the floor of the valley from the mouth of the river to the source, this slope being such that it steepens gradually upstream. The valley sides also acquire, in time, a relatively stable profile, which is normally steeper upstream.

When this condition of balance has been attained, the river valley is said to be graded. Similarly, the tributary valleys become graded in turn, the vertical depth to which they can be eroded being determined by the level of the point at which they enter the main stream. The whole drainage system thus reaches a graded condition. In arriving at this condition, each valley passes through a young or immature stage before attaining the later or mature stage. If no fundamental change takes place in the region, this graded state persists, the only changes that occur thereafter being a general flattening of the floor and of the valley sides. This stage of development of the drainage system or of a valley is sometimes referred to as the old-age stage.

If, however, the region in which the drainage system is established is elevated above its former level, the balance which had been attained is destroyed; renewed erosion will therefore occur, beginning at the mouth and spreading upstream. Also, the balance between the main stream and the tributaries will be disturbed, and each tributary will be re-excavated until the balance is restored. At a certain interval of time following elevation of the region, the main valley and the tributary valleys will present two distinct aspects. The portion which has been re-excavated will appear as a relatively young valley, and the portion upstream will still retain its mature or old-age characteristics. From the fact that it lies high above the floor of the re-excavated valley, such a valley is termed a hanging valley.

Applying these considerations to the Yellowstone Canyon, we recognize the valley between the Yellowstone Lake and the falls as of old-age type, whereas the canyon region presents young or immature features. The valley of old aspect was formerly continued downstream, but has been destroyed by the re-excavation which made the canyon. All the tributary valleys above the junction of the Lamar Valley are mature in their upper portions and youthful in their lower portions. We attribute the existence of the canyon to uplift or elevation, and the region of the falls marks the point to which the renewed erosion, following elevation, has extended up to the present.

If this were all the history of the Yellowstone Canyon, it would not differ markedly from that of numerous other canyons in the United States and in other parts of the world. A few hundred yards below the lower fall, Professor Field observed in 1926 a considerable thickness of what appeared to be sediments, perched high up on the wall of the canyon, as if they had been deposited there by the river in an early stage of the erosion of the canyon. An opportunity of closely examining these sediments did not present itself until the visit of the Summer School in 1928. It was in consequence of this detailed examination into the nature and extent of these sediments that we were able to arrive at the conclusions described in this article.

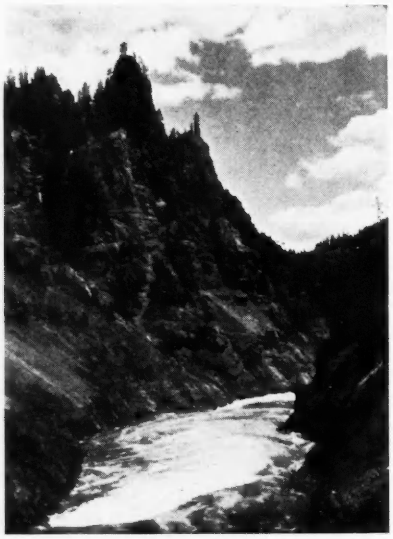


Fig. 3.
THE RED ROCK.
This prominent pinnacle overlooks the gulley in which the new discoveries on the geology of the Canyon were made by Professor Field and the writer.

These sediments occur in a narrow gully which passes behind a prominent pinnacle known as the Red Rock (Fig. 3), and opens at both ends into the canyon. They consist of alternating layers of coarse sands, gravels, and fine, muddy silts, with distinct banding or stratification. Particular importance is attached to the silts, because it is certain that they could only have been laid down in comparatively quiet waters; this in spite of the fact that the Great Fall of the Yellowstone is now only a few hundred yards distant from the Red Rock. Further examination disclosed, however, that similar sediments occur much nearer the fall, and within a distance of fifty or sixty feet from the bottom of the existing canyon. Moreover, they appear to form a considerable part of the wall of the canyon (Fig. 4) between the upper and the lower fall, presenting everywhere the appearance

of having been deposited in comparatively still water. The position of these sediments on the canyon wall proved conclusively that they had been laid down after the canyon had been excavated to nearly its present dimensions.

The topmost layer of these sediments consists of coarse gravel, cemented by calcareous tufa into a hard conglomerate, which forms the rim on both sides of the canyon between the lower and the upper fall. This curious conglomerate had been noted by previous observers, and it played an important part in the deductions which were drawn regarding the age and history of the canyon. Around the present Lake Yellowstone, and extending for some distance downstream, there occur extensive gravel terraces which indicate former higher levels of the lake. It was believed that the conglomerate between the falls was an extension to that point of one of the Yellowstone Lake terraces. Inasmuch as the latter were formed after the end of the glacial period, it seemed obvious that if the Yellowstone Lake formerly extended as far as the existing Yellowstone Falls, that part of the canyon at any rate could not have come into being until some time after the end of the glacial period. On this evidence, the canyon was regarded as of extremely recent geological age. Its extent and great depth were used as evidence of the enormous amount of erosion that had taken place since the end of the Ice Age.

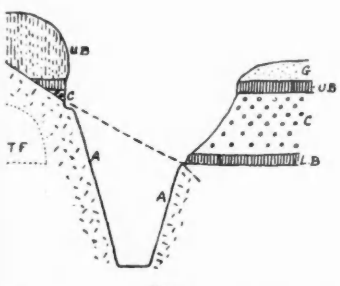


FIG. 5.
SECTION ACROSS THE CANYON NEAR TOWER FALLS.
A, Andesite breccia; LB, Lower basalt; C, Canyon conglomerate; UB, Upper basalt; G, Glacial deposits; TF, Lower basalt near Tower Falls projected on to line of section. (Figure here reproduced from the *American Journal of Science*.)

This conglomerate bed is, however, of totally different nature from the gravels of the lake terraces, and, moreover, is of much greater geological age than the glacial deposits in the neighbourhood.

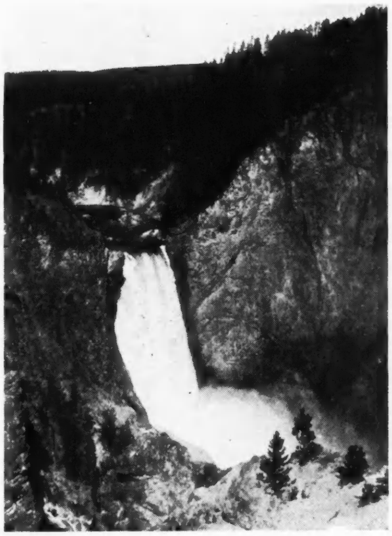


FIG. 4
THE CANYON ABOVE THE FALLS.
The sediments which give a clue to the secret of the Canyon form a considerable part of the walls above the fall, shown in this photograph.

It is impossible to conceive of any explanation of the beds of silt found at various levels on the walls of the canyon, except as the products of deposition in a lake. We are, therefore, forced to the conclusion that at some period after the canyon had been eroded up to the falls, a lake had somehow or other become established in the canyon, and in this lake sediments were laid down until ultimately the canyon was filled to its very brim with these deposits. A remarkable feature of the sediments is the repeated alternation of fine silts with coarse sands or gravels. Each silt layer in the upward succession indicates a fresh rise in the level of the lake which thus rose in successive stages until it finally occupied the canyon to the brim.

The part of the canyon near the falls offers no hint of the reason for the formation of a lake on the site of the pre-existing canyon. This was only obtained some twenty-four miles lower down, in the neighbourhood of the well-known and much-visited Tower Falls, about two miles above Camp Roosevelt. As previously described, the most striking feature of the canyon in this locality is the great sheet of basalt lava which rests upon a well-marked bed of river gravel. In places there is a second sheet of lava below the gravel. Further examination led to the conclusion that these basalts had flowed into the Yellowstone valley from the north against the direction of the drainage at a time when the floor of the valley was much higher than the bottom of the present canyon. It will readily be seen that if lava flows entered the valley in this manner, they would form a barrier or dam in the valley which would impound the water upstream between the lava and the walls of the canyon. A relic of one of these basalt flows resting on river gravel is still preserved in the wall of the main canyon, several miles above Tower Falls, and again many miles up the Lamar valley.

On reference to the geological maps of the region, published by the United States Geological Survey, it becomes obvious that many flows of lava had entered the lower Yellowstone valley from the same general direction, and that the lava ultimately attained

a height sufficient to block the whole of the lower Yellowstone and the lower part of the Lamar valley, and to form a great lake up to the level required for the deposition of the sediments in the neighbourhood of the Yellowstone Falls. Near Tower Falls one can see that the two basalt flows of the second canyon, and their intervening gravel, fill up an old valley which lies to one side of the existing canyon, and that the second canyon itself has been cut as a deep trench, in more recent times, in the flank of the old valley (Fig. 5).

During the glacial period it appears certain that the main canyon of the Yellowstone up to at least the Upper Fall was entirely filled with sediments; near Tower Falls sediments were interbedded with lava flows. In the lower Yellowstone the valley was filled almost entirely with lavas of which extensive traces still remain. In the subsequent period the Yellowstone valley was re-excavated through the lavas, and this led to a progressive removal of the sediments which filled the main canyon, leaving only the relics fortunately preserved, mainly near the falls. It appears, therefore, that the erosion of the Yellowstone Canyon, as well as its subsequent infilling, has been effected long before the glacial period, probably during the Pliocene era. The formation of the lake above the lava dam also in that era arrested the development of the canyon. The erosion in post-glacial times has only just proceeded far enough to remove most of the infilled sediments, and the great fall now stands nearly where it stood in the Pliocene era. The Yellowstone Canyon, therefore, presents us with a wonderful example of a canyon arrested in its development for an enormously long period, and the existing canyon may justly be regarded as a resurrected canyon.

The Progress of the Science Museum.

THE widespread and growing interest of all classes of the community in science and its applications is remarked upon by the Royal Commission on National Museums and Libraries, which has just completed its work.* In the course of dealing individually with the principal public collections throughout Great Britain, the Commission strongly urges the value of periodical exhibits illustrating recent discoveries and developments. At the Science Museum in South Kensington, where such exhibitions have lately been held, it is gratifying to learn that the attendances have nearly doubled within the past four years. In 1926 the total was 576,734; in the year 1929 it was expected to exceed 1,000,000. On public holidays the attendance is greater than at any other museum.

The report draws attention in another paragraph to the Deutches Museum at Munich, where the modern spirit of interest in scientific progress has found remarkable expression. This institution, opened in 1925, owes its existence to Dr. Oskar von Miller, its present director. It was his plan that the museum should be devoted to illustrating the development of pure and applied science, a living history of the spirit of research and discovery of every age and of all countries, an institution in which the results of scientific research and experiment should be fully shown. The museum was begun before the war, but it is only since the war that it has attained its present proportions. It consists of 340 exhibition rooms, the total area of the space is 360,000 square feet, while to pass through all the galleries involves a walk of about nine miles. Large additions are in process of erection to accommodate a technical library and a hall for meetings and lectures, with smaller conference rooms adjoining. The collections are arranged so as to show the ordinary developments of each subject from its earliest beginnings up to the present day. But, beyond this, another purpose has been kept in view: facilities have been provided for the visitor to conduct experiments himself. The Education Ministers of the most important States of the German Federation have impressed forcibly on all high schools and technical schools the importance of visiting the museum, with their senior classes, and of arranging for parties of science teachers to study the collections and the methods of their exhibition.

The Royal Commissioners call particular attention to this German science museum, not only because it is in itself a remarkable example of how a modern museum can be made a great instrument of technical as well as popular instruction, but because it is a symbol of national efficiency. It reveals the intense concentration in the Germany of to-day on the scientific means of industrial progress, a concentration which they believe has its sharp significance for Britain. It is notable that the Deutches Museum has been erected and equipped largely by the contributions of rich industrialists, and by the free services of architects, of engineers and (what is specially noteworthy) of workmen.

**Royal Commission on National Galleries and Museums.* Final Report, Part II. January, 1930. (H.M. Stationery Office. 2s.)

British Universities To-day : (2) Birmingham.

By Sir Charles Grant Robertson, M.A., C.V.O., LL.D.

Vice-Chancellor of the University of Birmingham.

This summer will see the Jubilee of Mason College, founded at Birmingham in 1880. From this beginning a University has grown up consciously adapted to modern needs, in particular to the requirements of a famous industrial area. Sir Charles deals, incidentally, with the problem of education for business, now widely discussed.

THE present organization and future development of the University of Birmingham cannot be understood without a brief recapitulation of its origin and the aims of its creators. As a provincial centre of higher education, it is like most of the other new universities, the product of the powerful educational movement which started in the 'sixties of last century, and which aimed at providing advanced instruction on a modernized curriculum for those who either could not afford to go to Oxford or Cambridge, or, until 1873, were debarred by the religious tests from matriculating and graduating there. The foundation of the Owens College at Manchester in 1851 provided both a model and an inspiration ; and Birmingham found its Owens in Sir Josiah Mason, who devoted the wealth, built up from zero by force of character and business ability, to the creation of Mason College, opened by Huxley in 1880. This college rapidly developed to cover both science and arts ; but, of course, it could not grant degrees ; Mason College students had to prepare for and to obtain the external degrees of the University of London. Further north, in 1880, the incorporation of the Federal Victoria University (Manchester, Liverpool and Leeds) had created a degree-granting institution, and towards the end of the nineteenth century the idea of inclusion in this northern federal organization was seriously discussed. But the powerful influence of Joseph Chamberlain was employed to reject the idea and to originate and carry through a decisive new departure.

A Landmark.

Birmingham and the Midlands were to have their own unitary (not federal) university, and not be amalgamated with any other institution. A Royal Charter was granted in 1900 ; Mason College was dissolved and re-created ; Chamberlain raised large sums for buildings, endowment and equipment ; the medical school founded in 1828 was absorbed. Not only was the University of Birmingham born in 1900, but its birth registered a landmark. It was the first provincial university to be created, centred in the capital of a large, definable, and industrial area, independent of all other university organizations, and planned to be the university of a province, but bearing the name of the chief city of that province. I am not concerned here with the effects elsewhere of this stroke of deliberate policy, which were far-reaching. It suffices to register the fact, because it has governed the ambitions and development of the University ever since.

Three other important characteristics must also be noted. First, the site of the new university was placed, not as in Manchester, Liverpool, Sheffield, and Leeds, in the centre of the capital (where Mason College was) but two and a half miles away on an undeveloped "campus" (given by Lord Calthorpe) of some sixty acres, where there would be ample room for expansion, and, in time, a residential university quarter could be built up. Secondly, the industrial needs (both in pure and "applied" science) of the Midlands were especially taken into consideration, and the departments of Engineering and Metallurgy and Mining were planned and equipped after a "commission" had studied and reported on the organization of such university developments in the United States and on the Continent of Europe. Thirdly, a Faculty of Commerce—the first and pioneer creation of any such university Faculty—was made an integral part of the scheme ; and the late Sir William Ashley was brought back from Harvard to plan and direct a novel enterprise—training through a course of university studies not economists nor economic teachers, but men and women, with the degree of Bachelor of Commerce, specifically for the career of business.

At its birth, therefore, the University had four Faculties—Science, Arts, Medicine and Commerce ; and like the Scottish Universities, on which much of its academic organization was modelled, it was non-residential. It was, also, co-educational from the start. Men and women were admitted on equal terms to all courses of studies and to all the degrees granted ; and the same principle was applied to appointments

on the academic or administration staff. One other feature must also be noted. The able creators, lay and academic, of the new University were well aware of the dangers that technology and technological instruction, particularly in science and commerce, involve in large industrial areas. They were determined that, alike in all Faculties, they were going to have a real University, and not merely a superior Technical College, or Polytechnic, containing a varying percentage of students working full time for degrees with a large admixture of part-time students, working mainly in evening classes for craftsmanship. At the outset, therefore, they laid it down that the University would accept only full-time day students (*i.e.* 9.30—5 p.m.) and that no evening classes (*i.e.* after 5 p.m.) of any kind would ever be given under University auspices and by the University staff. By "a gentleman's agreement" with the City of Birmingham, which has been scrupulously observed on both sides ever since, it was decided that all such part-time and evening work should be provided either at the Central Technical College, the Commercial College or the Birmingham and Midland Institute—anywhere, except in the University itself. It is not too much to say that this far-seeing decision, if it has kept down (a small matter) the numbers of those enrolled as University students, has been of incalculable value in building up and maintaining the standards, both for staff and students, of what a University education and degree really ought to be. After 1900, the University rapidly went ahead, and a substantial instalment of the comprehensive scheme for the Edgbaston site was opened in 1906 by King Edward VII. And then came, in succession, two blows—the incapacitating illness in 1907 of Joseph Chamberlain, rightly the first Chancellor, which took away the central driving power and the one man who could raise the large sums still necessary to complete the original plan, and then, just as recovery from this was being reached, the great war of 1914. Inevitably, the male students dwindled to a handful, but (what did not happen elsewhere) the War Office appropriated the Edgbaston buildings and converted them into a huge hospital, with the necessary auxiliary services.

Post-War Problems.

With 1919, the second chapter of our history begins. Not only was the University £138,000 in debt, but the military had to be got out of the University site and buildings (not an easy matter) and the buildings re-organized, renovated and restored, the whole University life re-created, and provision made for more than 700 ex-service students, in addition to the normal 1,100 or 1,200 whom peace brought clamouring to its doors. From 1920 onwards the University has wrestled with these inherited problems, with new ambitions, and, from 1920-1927, with the economic difficulties created for a large industrial area by unemployment and the dislocation and re-organization of the industries and trades, without which the Midlands cease to be what they can and ought to be. Often in those years, when I was visiting Oxford or Cambridge, the uppermost thought in my mind was: "We in Birmingham know what unemployment means; in these happy and sequestered homes of the human spirit the world that roars at our Midland gates cannot be heard here, and does not seem to matter."

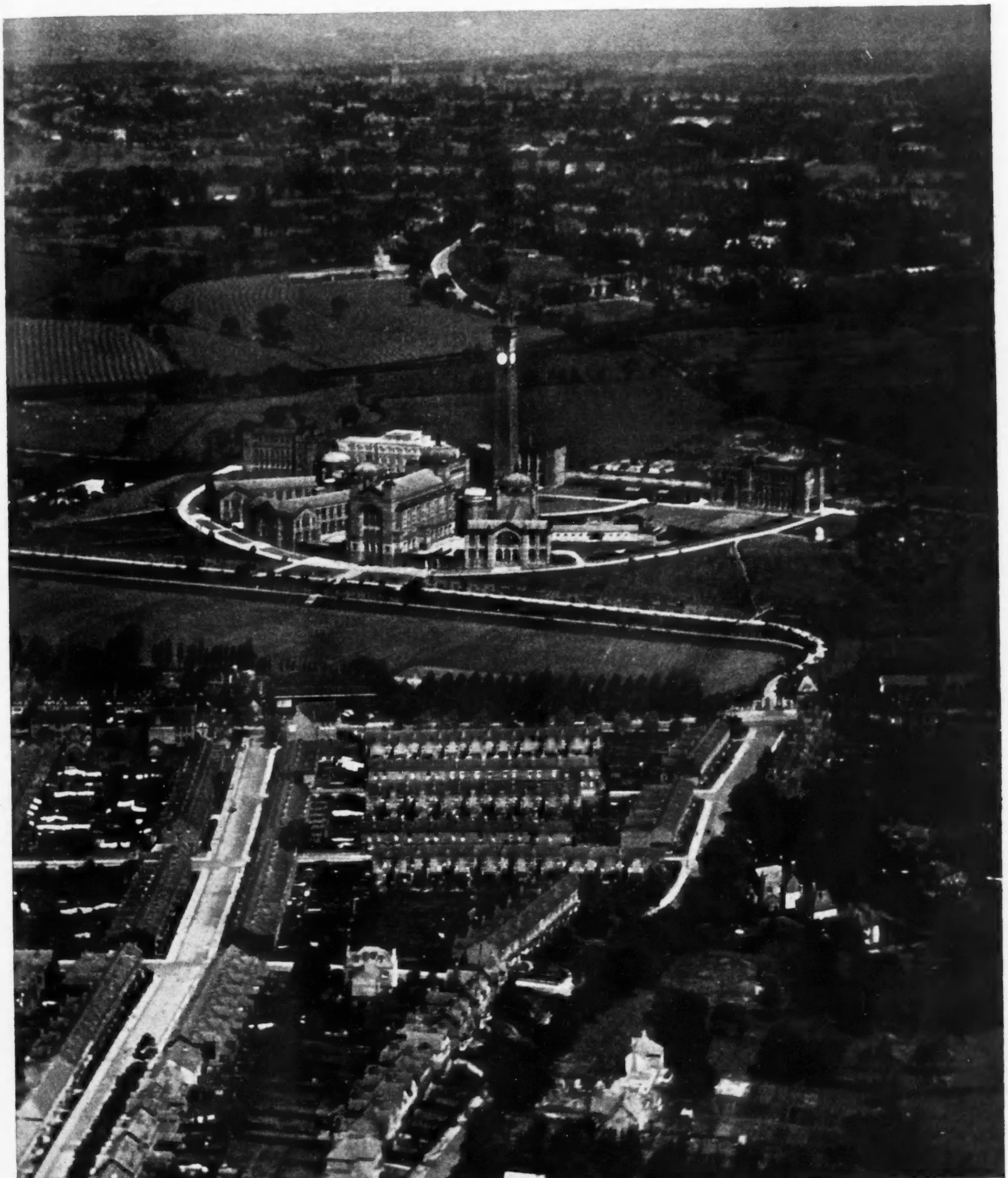
Eppur si muove. Despite the iron decade through which we have passed, if we have not realized completely the ambitions of the Founders of 1900, or our own dreams, born after 1919, we have not been standing still.

Rapid Development.

We have cleared off our capital debt of £138,000; and, thanks to many generous benefactors, raised besides at least £300,000 for extensions, equipment, some seven or eight new Professorial Chairs, additional staff, and a substantial improvement of staff stipends on a carefully graded scheme. The Calthorpe family has added to its original gift of land, and this, with the purchases made by the University itself, has brought the "University campus" at Edgbaston up to some 140 acres, which, so far as we can see, ought to provide for all future requirements, both for teaching, libraries, athletics, and recreation: we have brought into existence two Halls of Residence for men and women undergraduates respectively, and, by a close connexion with the old foundation of Queen's College, have really another Hall for some fifty male students; and this year, when we celebrate the jubilee of the foundation of Mason's College, we shall hope to open the new Student's Union (Club House) which will be as complete and as attractive as any similar Union anywhere. We also hope soon to have a second Hall of Residence for women students.

Not less important, in 1926 we created a fifth Faculty, that of Law, which already has very nearly one hundred students in its various courses, and which has established a new liaison with a great profession which is singularly well organized in Birmingham.

Naturally, the work of the University in its five Faculties resembles closely that of most universities, and does not require detailed analysis here. One or two special features, however, merit a word. Our



Aerofilms.

BIRMINGHAM UNIVERSITY FROM THE AIR.

Engineering School is carefully articulated in Professorial Departments—Mechanical, Civil, Electrical, Mining, and Petroleum. In the last-named subject we are the only British University with a specialized Department, requiring four years' work for the degree of Bachelor of Science, and, thanks to liberal support from the great oil companies, it is finely equipped, and the graduates are rapidly absorbed by the industry. Our Mining School has special features in the Research Department, under its director, Professor Haldane; the Fuel Treatment and Mining Machinery Laboratories and the Scholarships provided by the industry for bringing young men from the old and endowed "public" schools into training for the profession of Mining Engineer. From 1880 onwards science naturally played a predominant part in our organization, but in the last ten years the development of the Faculty of Arts has been rapid and thorough, and we have now in that Faculty almost as many students as in Science, with Honour Schools in all the leading subjects.

A Committee of Research.

From the first, the encouragement of post-graduate and "research work" as the normal completion of University studies for the best students has been a special point of University policy. In 1921 we instituted a standing Committee of Research, composed of laymen from the University Council, and Professors from the Senate, whose function it is to frame a general policy of research, allocate such funds as are placed at its disposal, and assist all approved "researchers" in obtaining funds from outside sources. The annual report of this Committee, specifying all work accomplished or in progress, circulates very widely, and other universities have paid us the compliment of setting up similar committees for similar purposes. The items that appear in that report are at least varied, and may include topics as diverse as some chemical substances, with a title like that of four Welsh villages in one, a Wordsworth MS., the odontology of pigs, the policy of France under Loubet, and the reactions of adolescents as a proof or disproof of "Behaviourism." At any rate, we are proud of having a Nobel Prize winner on our roll in Dr. Aston, F.R.S., born, bred, and trained for many years in Birmingham before we passed the finished product on to Cambridge and the Cavendish Laboratory. And amongst our women graduates is now a well-known "film star," who perhaps some day may remember the rock whence she was hewn. Nor do we forget that both Mr. Baldwin and Mr. Neville Chamberlain were once students at Mason College. The existence of Mason College in the centre of Birmingham is a perpetual reminder, not only of our origins, but of our incompleteness—or rather that our comprehensive scheme still awaits completion. For the University of Birmingham is divided into two parts, two and a half miles apart—the Edgbaston site of 160 acres, where are Science and Commerce, the Playing Fields, the Student's Union and the adjoining Halls of Residence, and Mason College, the crowded and busy hive of Arts, Medicine, Education, and Law. And a touch of modernity is indeed given when at certain hours on certain days a large and comfortable motor bus discharges at the entrance to the college a platoon of young men and women from Edgbaston, who disappear at the double and treble to their appointed lecture-rooms, and picks up another platoon to be conveyed as fast as the police will allow to Edgbaston for some lawful academic purpose—"artists," maybe, who are hot-foot for economics, or educationists in search of instruction in biology. A modern University in a mechanical city is not going to allow two and a half miles to waste time and temper in the pursuit of truth! We also know that our final spiritual home is on the University campus at Edgbaston, and that some day, and probably soon, Mason College (it is a valuable freehold site in the centre of Birmingham) will be sold, and the Faculties working there transferred to their final and appointed sites. And, as each new building or new road comes into existence "out there" (where it has all been carefully mapped out by skilled town-planners) though we of this particular University generation may not reach the Promised Land, we can see the united University of our dreams. In the young Universities hope deferred braces the heart, stiffens the will, and fires the imagination. We have seen so many dreams come true, that we believe it is only the dreamers who are the practical realists.

New Medical Schools.

And to-day we are just about to launch one more of our ambitions that has been put together, bit by bit, in the last four years. This will involve the complete re-organization of our Medical School. The plan, briefly, is to build a new teaching hospital planned on the most modern ideas and experience, and to transfer the Medical Faculty of the University, with all its scientific laboratories and departments, from their congested quarters in Mason College to a new site of twenty-five acres additional to and adjoining the "University campus" at Edgbaston. The lay-out of the scheme has been so designed as to combine the hospital wards, the operating theatres, the teaching, lecture-rooms, etc., and the scientific

laboratories for research, instruction and hospital routine work in an organic unity, and thereby facilitate the closest connexion between the clinician, the scientist, the medical staff engaged in treatment, and the medical student ; and to link up the whole, also, with the University and with the Faculty of Science in particular. When completed the new hospital will be *the* central Teaching Hospital for the University as well as the main nucleus for a developing hospital centre for Birmingham and the Midlands. Our Medical School is more than a century old, but the new scheme, which will take five to ten years to complete, ought to make it both a pioneer in the organization of medical teaching and a model of the union of scientific knowledge and clinical experience in the treatment and prevention of disease, and in the training of surgeons, physicians, nurses and researchers.

The Social Factor.

A young University, such as Birmingham, which has kept in real touch with the cultural needs and industrial demands of a large and definable area is necessarily provincial, in that probably eighty per cent of its students will be drawn from its sphere of influence, but it can also be " of the centre," if it frames its policy and its standards on those " of the centre." Its history will then be a microcosm of the larger national world. We can now look back on thirty years of unceasing, if slow and steady, development, and we can trace the phases through which we have passed, and the goal—itself slowly altering—towards which we press. In their origin, the provincial Universities, largely based on the Scottish model, simply aimed at providing higher education for those who lived at home and could not go to Oxford or Cambridge, and at training the technicians that the provincial industries required and readily absorbed. In that dual task, by meeting the needs, we have exerted a powerful shaping influence on secondary education, and on the conception of science and its applications in industry. But something much more subtle and valuable has, also, been accomplished. The interpretation of university life and education has been revolutionized. Recreation, physical and mental, has been brought in as an indispensable element in the higher education. An organized social life is now accepted as the prerogative of the University student. Halls of Residence, with the communal life of a college, are more and more demanded. Most of our students are of modest means, some come from very poor homes. In the University they learn things undreamed of in their own or their parents' philosophy ; above all, they learn that for the University teacher and the University student *class consciousness*—the bane of British politics and economics—has no place. The provincial University is, therefore, one of the most dynamic, regenerative, and unifying social forces in our British world of to-day—working all the more effectively because this side of its influence is neither openly proclaimed nor advocated amongst ourselves.

Meanwhile, each provincial University is steadily building up its own provincial tradition and ethos. In Birmingham we want to share in " the centre," but we are the Midlands—we know it, and are proud of it—and we want to compete *as the Midlands* with Lancashire, or Yorkshire, or Scotland ; and while we are ready to learn all that Oxford and Cambridge can teach us, we are not, and never intend to be, an anæmic and cheap copy of the ancient Universities which we admire, yet to which we are impertinent enough to think that in some respects we can teach something—if they will condescend to learn the lesson !

Nor are we megalomaniacs. At present we have in Birmingham some 1,650 students who come to work—and do work ; before long we shall reach a total of 2,000, and then we shall stop. We have no wish to teach everything—to have Departments of Assyriology or Byzantine Archaeology, or of every sub-division of every science. The large branches of human culture—the sciences and the arts—we must have, indeed we already have them. Our aim is like that of the good bridge player, to develop strength in our leading suits and to discard from the weak ones. In industrial technology we readily leave the textiles to Lancashire, wool to Yorkshire, marine engineering to Newcastle, Glasgow, or Belfast. But, above all, we believe that in industry it is pure science that matters, and that mathematics, physics, and chemistry are the basis of university and industrial efficiency and advance. The best service a university can render to business is to train the mind, for the mind's sake, and develop science for science's sake.

Building for the Future.

We also believe that dignity and beauty, simplicity in university buildings—the amenities and the lay-out —are of supreme importance, both intrinsically and in their effect on the young human mind in its intellectual toil ; and, therefore, we are building and planning, not for to-day mainly—though we want to see our dreams realized here and now—but for a future which we know will probably not be quite the future that we picture. Above all, in Birmingham, *we are alive.* Let the pessimist about our national future or about the youth of to-day come and visit us, and we will cure him.

A Naturalist in Basutoland.

By Hugh Scott, M.A., Sc.D., F.L.S.

A recent excursion into the mountains of Basutoland drew the writer's attention to some interesting problems in natural history. The specimens obtained have yet to be fully studied, but there seems no doubt that this South African territory holds many secrets for the collector to solve.

BASUTOLAND offers much to interest the student of mountain fauna and flora. It lies at the principal watershed of South Africa. The Orange River flows from its mountains westwards across the sub-continent to the Atlantic, while the Tugela and many shorter rivers run down south-eastwards to the Indian Ocean. Its territory includes, on the north-west side, the Maluti Range, rising to 10,000 feet in Mount Machacha. The south-eastern and eastern frontiers are formed by part of the Drakensberg. The area intervening between these two is a maze of lofty ranges. Mont-aux-Sources, South Africa's highest mountain, reaching over 11,000 feet, stands at the north-eastern corner of the country, and holds in its recesses the sources of the Tugela and of the Orange with its tributaries the Caledon and Elands.

How are the fauna and flora related to those of the adjacent high veld? Are some forms confined to small areas at very high altitudes and, if so, are they peculiar to Basutoland alone, or do some species reappear in the mountains of the Cape Province, far to the south-west, or in other more remote African mountains? We know some remarkable cases of discontinuous distribution and restriction to small, very elevated areas. On the other hand, some species common at lower levels reach great elevations as well. There is much of this kind to be worked out from a bio-geographical and oecological standpoint. In pursuance of such problems, I took advantage of a stay in South Africa to make a rapid entomological reconnaissance of parts of Basutoland. Maseru, the capital, on the north-western border, is linked to the South African railway-system by the only line in Basutoland. The western borders in general are less rugged and have a few roads for wheeled vehicles, but the rest of the country is traversed only by bridle-paths. I penetrated some distance into the Maluti Mountains from Maseru, and afterwards made a three days' journey by horse from Witzieshoek, O.F.S., to Mont-aux-Sources, and thence to the Drakensberg National Park in Natal. The districts accessible to me in a short time are, by all accounts, very fair samples of the whole.

THE APPROACH TO THE MALUTIS.
Kafr corn is seen in the foreground, with rock flat-topped hills and the high green range in the distance.

NATIVE LOCATION AT MASERU.
Basuto women adopted the crinoline from Europeans long ago, and the fashion is still kept up. The effect is achieved by wearing a number of flowing dresses.

The human history of Basutoland has profoundly affected its natural history. The bushmen who were its sole inhabitants have been replaced by the present Bantu race since the victories of Moshesh and his founding of the Basuto nation just under a century ago. The Basuto now number over half a million, and their increase and vigour have led to the destruction of most large wild animals, while extensive deforestation has left, for the most part, only low dense scrub in precipitous places. I saw no high forest till I reached the valleys of Natal. Though more

IN THE MALUTIS.

View from the highest point where collecting was done, at about nine thousand feet, near the top of a pass.

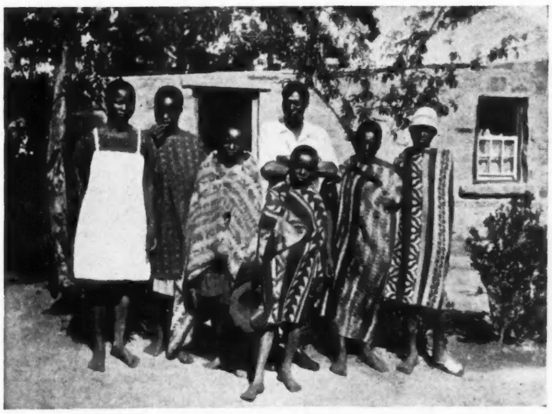
than half the surface of Basutoland is too rugged for habitation, every possible acre is under cultivation of mealies (maize) or kafir corn (*Sorghum*), and the steep grassy slopes are given up to grazing.

In the early stages of their history these people were one of the few native states able to resist the Zulus. The great victory of Moshesh over the Matabele, which led to the founding of the nation in 1831, was gained on the flat top of Thaba Bosiu, "The Mountain of the Night," less than twenty miles from Maseru. The site of the victory has since been made a cemetery for the great chiefs, and Moshesh, his son, and others lie buried under graves of rough stones on the summit of this table-shaped hill, nearly 6,000 feet above sea-level. A steep climb up its side leads to the burial ground. In passing, it may be recalled that, after wars with the Boers, Moshesh placed his country under the British in 1868. It is entirely a native reserve, the British Resident Commissioner has an advisory council of natives, and Basutoland is one of the South African territories which remain under the Imperial Government.

The Local Commissioner at Maseru, Captain H. Ashton, and other friends, helped me to reach Nyakoesuba, over thirty miles to the east. This was the furthest point attainable in that direction over mountain tracks by motor-car, and I used it as a base for going further into the hills by horse. The approach to the Malutis is characterized by flat-topped foothills and the lofty range in the background. Overdue summer rains were beginning and the mountains were green to their tops. There are patches of dark vegetation, a dense scrub of one of the few native bushes left. It is a Rosaceous shrub called "chichi," *Leucosidea sericea*, growing about five to fifteen feet high.

Small clusters of native rondavels, circular stone-walled houses with conical thatched roofs, are numerous, even up to very high altitudes. Rondavels look like Abyssinian *tukuls*, except that the latter often have wooden walls. The superficial likeness of Basutoland to Abyssinia naturally impressed one comparatively fresh from an expedition in the latter country. Though far apart, both are high, temperate lands, and their peoples, though of widely differing races, are both pastoral mountain nations. When I met Basutos swathed in gaudy-patterned blankets and wearing broad-brimmed, grass-plaited hats, riding sturdy ponies and uttering a friendly greeting to the passer-by, I almost felt myself back in Abyssinia.

At Nyakoesuba there is one of the stores where goods are supplied to the natives. I slept at the storekeeper's house, hired a native guide and two ponies, and rode into the mountains. The altitude of Maseru is about 4,900, that of Nyakoesuba about 7,800, and my furthest point was near 9,000 feet. In these treeless hills a collector of small insects has largely to sweep herbage with a net and search for ground-living forms under stones. At my highest point, near the top of a pass, excepting thickets of chichi bush at the base of overhanging rocks, the slopes were clothed with long, bright green grass full of flowers—clumps of blue *Agapanthus*, a large scarlet *Gladiolus*, a tall *Kniphofia* ("red-hot poker"), white arums, delicate blue lobelias trailing in wet places, scabious, and many Compositae. Little can be said yet of the miscellaneous haul of the sweep-net, but among the insects under stones were cockroaches of two species, one of them being a species of *Poeciloblatta*, in which the females apparently brood over their offspring. Under many stones I found a little pocket in the soil, out of which ran a full-grown female and a number of partly-grown young. Few species of cockroach are known to display maternal solicitude,



GROUP OF BASUTOS.

The boys on the right wear blankets with red patterns, a common form of native dress, said to replace the skins formerly used.

MONT-AUX-SOURCES.
A view taken from the Elands Valley on a dull drizzling afternoon. The scrub in the foreground is chichi (*Leucosidea*).

but in some cases incipient social habits may be traced, a significant fact in view of the close morphological and phylogenetic connexions between cockroaches as a group and termites.

Butterflies were scarce, probably owing to the previous drought. But the lack of bright-coloured flying things was made good by the birds, especially the males (in full breeding plumage) of three kinds of weaver-finches which flitted in numbers over the mealie fields.* A pair of Malachite sun-birds was nesting in a chichi thicket where I sheltered from an afternoon rainstorm. Thick scrub of chichi and other bushes, and rank weeds, among which the narrow, down-turned scarlet trumpets of "Cape Figwort" (*Phygelius capensis*) and the flower-heads of a tall white Dipsacus were prominent, covered the precipitous sides of a kloof below a waterfall. The stream was low and I searched for ground-living insects in the bottom of the ravine, and could have wished to stay longer and collect by beating and shaking the foliage of the scrub.

The Rydal Mount Hostel at Witzieshoek is reached by motoring thirty-two miles south-west from Harrismith along a track over undulating veld. Witzieshoek, though in the Free State, is a native Basuto Location. It lies at an elevation of about 6,000 feet amid rolling veld with some rocky hills, outliers of the Drakensberg. I was joined there for several days by a very well-known naturalist, Mr. H. P. Thomasset, who came from his farm at Weenen, Natal, and who had been my fellow-collector in the Seychelles twenty years earlier.

From our collecting at Witzieshoek has emerged at least one biological fact, concerning the life-history of a small beetle, *Urodon lilii*. Among other entomological and botanical material I took seed of a Watsonia (Order Iridaceae), and accidentally found adults and young stages of the *Urodon* in the seed-vessels after my return to England. *Urodon* is a genus of debatable systematic position. Its Palaearctic representatives haunt (in the adult state) flowers of Cruciferae and Resedaceae, and certain of them are known to pass their life-cycle in the seed-vessels of common wild mignonettes (*Reseda*). It is remarkable that the first South African species, about the life-history of which anything has come to light, has a food-plant of an Order so remote taxonomically from those of its Palaearctic congeners.

I started for Mont-aux-Sources and the National Park with a Basuto guide and three horses, respectively for myself, the guide and our kit. A ride of eighteen miles, first over rolling veld, then up the ever-narrowing valley of the Elands, brought us to the foot of the mountain. After thunder and hail the day before and heavy rain in the early morning, we were fortunate in easily negotiating the Elands, which we crossed and re-crossed at about five different fords. At the foot of Mont-aux-Sources I slept two nights, ascending the mountain on the intervening day. Visitors used to camp in some low, wide caves, but the proprietor

HILLSIDE VEGETATION
Rank flowering weeds on the steep sides of a kloof, with tall and thick scrub of chichi and other shrubs behind.

*The scarlet and black Bishop-bird (*Pyromelana oryx*), the black and yellow Bishop-bird (*P. capensis*), and the Long-tailed Widow-bird (*Chera procne*), the male of which is black with scarlet patches in the wings and has a very long, trailing black tail.

of Rydal Mount has provided a kitchen-hut and a rondavel, in the former of which my guide slept and cooked, while I spread my kit on the floor of the latter. The caves were serving as night shelters for some of the Angora goats kept by the Basutos. The Elands valley is here deep and narrow and thickly clothed with chichi bush. The scrub and trees consist principally of this shrub (*Leucosidea*), buddleia-bushes, sugar-bushes (*Protea*) and queer cabbage-trees (*Cussonia*). The foliage of all these has a prevailing bluish- or greyish-green tone. The cabbage-trees stand like sentinels along the very edge of precipitous ravines. The sugar-bushes are representatives of an Order (Proteaceae) which bulks very large in the flora of South Africa, and to which the famous silver-trees of the Cape Peninsula belong.

From the rondavel, at about 7,000 feet, to the Basutoland frontier police huts on top of the mountain, is a climb of about 4,000 feet, most of which can be ridden both going up and coming down. The thousand feet nearest the top, over very steep zigzags and loose slippery stones is, however, best done on foot. The top of Mont-aux-Sources is a flat, bleak moorland about 11,000 feet above sea-level, and we cantered over it for about half-an-hour from the police camp to the huge precipice over which the Tugela leaps in a series of falls of more than 2,000 feet. February is not the best season for the ascent as regards weather, and on this occasion low cloud and rain in the early morning gave place to a very cold, high wind and driving showers while we were on the top. But during sunny intervals I enjoyed the vast prospect from the edge of the precipice over the valleys of the National Park and the further parts of Natal, 4,000 feet and more below. The inclement weather was amply made up for by the splendid array of flowers seen on the way up, and some had the low, tufted form of real alpines. Even on the bleak top moorland, wide stretches were starred with low mauve Composites and white Everlastings (*Helichrysum*). Quantities of little black flower-beetles (*Meligethes* or an allied genus) were found in the yellow flower-heads of a low, tufted Composite. I took little else on the actual summit, where both collecting and photography were made very difficult by the wind and rain. But in the steep, sheltered kloof just below the police camp, weevils and other small beetles were swept in profusion from flowers, especially from shrubby Compositae.

THE SUMMIT OF MONT-AUX-SOURCES.

Photograph taken at 11,000 feet, looking from the edge of the Tugela Falls precipice to the Devil's Tooth. Notice the distant view over Natal on the left.

IN THE DRAKENSBERG NATIONAL PARK.

Scattered proteas and other trees grow here on the grass slopes, in contrast with the treeless mountain tops.

How far the species collected are confined to very high altitudes cannot be stated yet. But we know that the fauna and flora of these mountains includes forms with a remarkably discontinuous distribution, restricted to high altitudes and high latitudes: witness two kinds of mosses found at 8,000 feet on Giant's Castle in the Drakensberg, one of which is only known elsewhere from some of the highest Andes, from Mt. Everest at 19,800 feet (the highest point at which a moss has ever been gathered), and from a single locality in Reunion, while the other species has only been otherwise recorded from Ecuador, Fuegia, New Zealand, Tasmania, and some of the subantarctic islands. The former is *Aongstroemia julacea* (Hook.) Mitt. and the latter *Ditrichum strictum*—facts to which Mr. H. Neville Dixon, F.L.S., kindly drew my attention. The Basutoland mountains must hold many secrets of a like nature. The country is less than 150 miles across and fully equipped expeditions traversing it, with horses and camp outfit, and with time to spare, will doubtless be well rewarded.

A Native Returns to Scotland.

By Capt. C. W. R. Knight.

Recently the author released on a loch in the Highlands a pair of osprey which he had brought back from America. Whether this reintroduction of a bird once native to Scotland will succeed it remains for the future to prove. Ospreys last nested there about ten years ago.

WHEN I took my golden eagle from the Scottish Highlands to the United States of America, with the droll idea of showing the Americans the faults in their coinage engravings—of course I had other objects, but the whimsicality of this appealed to me—I had little idea of the splendid good fortune which awaited me in New York. Not only did my eagle excite a great deal of attention, but I met Mr. Clarence Mackay, the lessee of Gardiner's Island, a sanctuary for ospreys or sea hawks, and Mr. Lion Gardiner, its owner. They kindly gave me permission to study and photograph on the island, and when the thought struck me that it would be a good thing to re-establish the osprey in Scotland, they entered into the scheme with enthusiasm. I had also, as soon as I sought it, the kindest co-operation from the Duke of Sutherland and Colonel Cameron of Lochiel.

A Dashing Bird.

Lest readers be misled, it had better be explained at once that the osprey is a sea hawk living on fish entirely, a dashing bird with tremendous pinions and exceptional rapidity of movement, its plumage being brown and grey with underpart white. It is not the bird from which feathers so beloved by the fair sex are obtained. The osprey plumes which at one time were the sign of a smart headgear came from the egret, a totally different creature. The sea hawk is somewhat larger than a peregrine falcon and, with its hooked bill, glittering golden brown eyes and particularly sharp and powerful talons, it has a wild appearance. When fishing for food the bird swoops down like a flash, and dropping its head into the water it reappears bearing a fish in its talons. Then it soars upwards again and away, seemingly without effort. The eggs are beautifully coloured and about as large as a hen's. The ground is cream with rich reddish-brown markings. The nest is an enormous structure of branches lined with seaweed. The fact that many of these branches are as much as two inches in thickness and over three feet in length shows the great strength of the builders.

I made arrangements to bring back some ospreys from Gardiner's Island for release on the Scottish lakes, in the hope that they would become acclimatized, mate and nest in their new home, and eventually breed and re-stock the country.

At one time ospreys were common in the Highlands. They haunted the Lake of Menteith, Loch Lomond, Loch Tay and other famous waters. About thirty years ago Loch-an-Eilan was a noted breeding place. They had bred here from time immemorial, but during one season the nest was twice robbed of all its eggs. The birds then deserted Loch-an-Eilan and never returned. The last ospreys in Perthshire nested on Loch Ordie in the spring of 1887. The parent birds were shot and the nest removed to Perth Museum. The later history of the osprey in Scotland is a dismal record of persecution, ending in its extinction as a breeding species. It is now only [illegible]t with as a rare straggler from other lands. A[illegible]h s[illegible]sed to be protected by law, new arrivals nearl[illegible]ell to the gun of some ignorant person. [illegible]he Victorian period it was considered fashionable to possess ornaments of stuffed birds, and the magnificent sea hawk was hunted and shot down, whilst the desire to possess a clutch of its beautiful eggs was the ambition of egg collectors.

The American Sanctuary.

At Gardiner's Island, off Montauk Point, Long Island, I spent a couple of months in photographing and filming the birds, and I calculate there must be between three and four hundred nests in this splendid sanctuary. Ordinarily the osprey nests only in tall trees, but on Gardiner's Island, where they seem to understand that they are protected, the birds nest on rocks, in fields, and even in the seaweed on the beach. Some of the photographs I have taken show that several accepted theories about the osprey are incorrect.

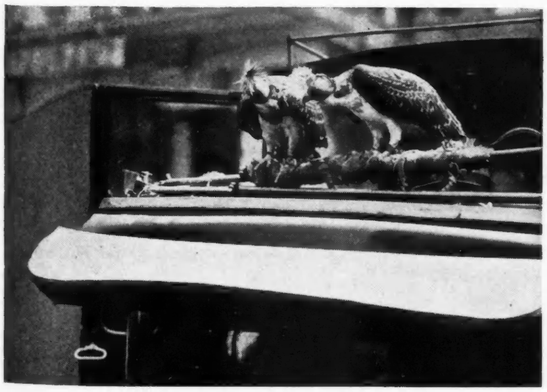
The two pairs of young sea hawks I brought back to England had a very unpleasant journey, for they had to remain in the hampers all the way, but once arrived home I hooded them and commenced training. I taught them to swoop down on to their food whether thrown on the ground or in the water. Eventually they were quite capable of looking after themselves, so

I thought the moment had come for the first experiment. Therefore, quite recently I took two of these birds to Scotland, and on an island set in the midst of a beautiful loch I released the first bird. The next day the second one was set free, and whilst we were engaged in doing this we saw the freed osprey sailing along at the height of some sixty feet above the loch, as though it was acquainted with every yard of it. What a magnificent flier and what a grace and beauty it added to the surroundings! It is too early yet to state anything definite, but I am sincerely hoping that the two birds, who are in no way related, will settle down and rear a family.

This second day was in every way thrilling for me. The experiment meant so much which cannot be explained in writing, but which will be understood by true lovers of animal and bird. There was a thick Scottish mist as we anxiously set out for the loch. As we approached we heard a buzzard screaming from the direction of the osprey island, and presently we saw him wheeling in the air above the loch. Immediately I guessed that the free osprey had been indulging in a little exercise and that the buzzard, having seen it and "recognized a stranger," had set up his usual mewing cry. On the island we found, as I had expected, that the free [illegible]sprey had gone but had made a good m[illegible] bef[illegible]d, since there remained only abo[illegible] fish [illegible] with him when first released. He wou[illegible]vever, know where to look for food if he should feel hungry and not care to swoop into the water for a fish. A couple of fresh, skinned rabbits (for I had discovered that ospreys are very fond of skinned rabbits) and some more fish were placed near the stones, and the second osprey had one of her jesses removed. The other was cut

RELEASING THE OSPREY.

The author is seen about to release one of the ospreys which are now at large on a Scottish loch, after this interesting species had been absent for many years.



STRANGE TAXI PASSENGERS.

The two ospreys on their way back from America, photographed in a taxi outside Charing Cross Station. The birds attracted an eager audience of spectators.

through close up to her leg, and then she was free! Once more we crept back to our boat and rowed silently away, so as not to frighten her.

Our friend the buzzard had been sailing overhead most of the time, but as we rowed out from the island he disappeared towards the mountains. We were all a little sorry and disappointed that we had seen nothing of the freed osprey, and inwardly, I believe, we all wanted to go back and explore the second island to see if anything could be seen of the bird, but none of us dared suggest it because it might have frightened her. Then with what suppressed, tense excitement one of our party gasped, "There she is!" Sure enough, there she was, sailing along above the loch. We watched her as she circled the island and then made off towards the far end of the loch—a distance of twelve miles. She looked magnificent, and we all gazed in silence as she swung to the right behind some trees and disappeared from view. "What a flier!" was the remark that at length broke the silence. Our job was done. I felt elated and satisfied, but now eagerly await reports on the birds' movements. I know her mate is as good, and one can only hope that, in these days, when stuffed birds are no longer desirable ornaments, and the egg collectors a little less drastic, the two will settle down. How delightfully romantic would it be if once more they were to build a nest and rear a family on that tiny island where their kind were fostered years ago!

It may be remembered that after an absence of over half a century the Capercailzie was successfully reintroduced to Scotland in 1837, so there would appear to be no reason why the osprey, if left in peace, should not likewise re-establish itself.

American Research on the Motor-Car.

The January issue of the "Scientific American" is mainly devoted to motor-car problems and the progress that has been made in the past ten years by manufacturers across the Atlantic. The following extracts from the more important of these articles include particulars of a new model using front-wheel drive.

EVER since the repeal in 1896 of the Locomotives on Highways Act, which provided that mechanically propelled vehicles should be preceded by a man with a red flag, enormous developments have taken place in the design and construction of motor-cars. Constant research and careful experiment have resulted, particularly in recent years, in so many valuable discoveries that it has been difficult to keep pace with the vast improvements introduced almost week by week. Perhaps no period has seen so many developments, both in engine construction and in body design, as the last ten years, particularly in America, and the following extracts from articles in the "Automobile Number" of the *Scientific American* give some idea of the progress which has been made by motor-car manufacturers in that country since 1920.

Many Problems.

The relationship of industrial research to the automobile, writes Mr. C. F. Kettering, Vice-President of General Motors Corporation, is a very intimate one, for it is only as a result of an immense amount of experiment that we have the motor-car at all. The motor-car is said to have been made possible by three things: Rubber, alloy steels and petroleum. That is the truth, perhaps, but it is not the whole truth, for the scientific and practical developments which have made the modern car possible came from a great many sources. Electric lights, for instance, are essential to the utility of the motor-car, but without the single development of ductile tungsten it would have been impossible to have put electric lights on automobiles. It was the search for smokeless powder that constituted the first of the long series of hard-won battles which have made possible the durable and attractive lacquer finishes on cars to-day. One of the principal problems that had to be solved in connexion with the use of lacquer finishes was that of securing suitable solvents for nitro-cellulose, and of providing them cheaply enough and in adequate amounts. This problem was finally solved by the combined efforts of the bacteriologist, the synthetic chemist and the chemical engineer; but it was not solved without a great deal of patient research. The motor-car, being the ultimate consumer of many types of manufactured goods, benefits from the research carried out in the industries which supply it. If it had not been for the discovery of high-speed cutting tools, for instance, it would not be possible to make cars as cheaply and as accurately as they are made to-day.

Mr. Kettering asks his readers to suppose that ten years ago a brand new car had been sealed up in a glass case, and left untouched until this year. The price of the car in 1920 was £300 and it is still in perfect condition, untarnished and without a speck of rust. The car is just as good as it was the day it was made, but it is safe to say, Mr. Kettering suggests, that the car is only worth one-third of its original price to a prospective purchaser to-day. The other two-thirds represent the figure at which the customer estimates the value of the research and the engineering work of the past ten years. In the engineering features of automobiles there has been an immense amount of persistent research. Constant experiments have been made in the construction of engines, their lubrication and cooling, and on improving their balance and the smoothness with which they run. The question of valves and the means of opening and closing them, combustion chambers and the means of getting ignition and controlling it, carburetion and atomization of the fuel, and the means of equalizing the distribution of charge to the various cylinders are among the countless engineering problems lately investigated afresh.

Perfection not yet Reached.

Although the motor-car of to-day is a vast improvement on the 1920 product, the final stage of perfection has by no means yet been reached. Exhaustive research is still being pursued in the motor industry, which is better organized than ever before, and more and more effort is being expended to introduce further improvements. Mr. Kettering concludes his article by suggesting that if one of America's best 1930 models were to be sealed up in a glass case now, the customer of 1940 would not think it worth any more, by comparison, than we think the 1920 car is worth to-day.

The perfection of racing cars and the gruelling

tests which they undergo teach valuable lessons to the automobile manufacturer, and many recent developments in the construction of motor-cars have been born of the "speedway." The motorist who switches on the ignition in his car at the curb, writes Mr. William F. Sturm, the well-known writer on American racing matters, may not perhaps realize that the almost perfect ignition of the modern car is due in part to the demand of the racing driver to have a type of ignition which will withstand the test of speedway racing. For it is no secret that one of the most successful types of ignition used in the motor industry to-day was perfected as the result of the extreme demands of racing.

The average car owner feels aggrieved if he cannot take his machine out and run it at high speeds for hours. He can only do it because so much has been learned from speedway racing concerning lubrication. One of the most important factors in the automobile engine of to-day is proper lubrication, and speedway races have done much to develop the pressure-feed oiling systems that are found on modern cars. The high compression motor used by many factories to-day is a result of the need of the racing driver for an engine that will deliver the maximum speed without "knocking." Four-wheel brakes are not so essential on the speedways as they are on the road, but the first American engineer to use four-wheel and hydraulic brakes had his racing cars equipped with them, and gained much knowledge from their use in that way. Racing cars, since the speed has risen higher and higher, have been designed with an eye to balance, and one of the first essentials in this connexion is a low centre of gravity. This feature on the passenger car of to-day ensures balance at speeds far greater than were obtained during racing speed only twenty years ago.

Lessons of the Speedway.

Speedway racing has done much for the present-day front-wheel drive, which was first introduced on the Indianapolis Course in 1925. The first front-drive ran faultlessly, but as others were built and used they developed several "snags" which took years to eliminate. The problems which confronted the front-wheel drive, however, have gradually been solved under conditions much more rigorous than would ever be met with on the road, and it was a racing engineer who first applied it to passenger cars. After two years of experiment, the front-drive has so far developed that one of the most perfectly produced cars of the present day is of the front-wheel drive type.

The year 1920 ushered in the rule that cars must be of 183 cubic inches displacement, and saw the real beginning of the highly specialized racing cars. In 1923 the displacement was reduced to 122 cubic inches, and in 1926 it was again reduced to 91½ cubic inches. With the gradual decrease in piston displacement there was a definite rise in motor speed, and although manufacturers are not using such high engine speeds to-day, they have been able to gather much useful information from the speeds which have been attained on the racing course.

In this article in the *Scientific American* Mr. Sturm writes with authority on speedway racing, and its effect on recent developments in the design of passenger cars, for until a year ago he was a member of the contest board of the Indianapolis Speedway, and had been closely associated with it since its construction in 1909. During each year that a five-hundred mile race has been run at Indianapolis, he points out, there have been automobile factory engineers in attendance—car designers who come for a week before the race and stay for a week after. They do not come out of mere idle curiosity; they come because they recognize that racing is, in truth, the crucible of the automobile industry.

The Front-wheel Drive.

The front-wheel drive to which Mr. Sturm refers is described in fuller detail in a subsequent article dealing with this improvement as applied to a pleasure car. The history of the front-wheel drive car is mostly a racing history, but while racing has its interest to the public most car owners want to know what the front-wheel drive has to offer them. The opinion of automobile engineers is that the chief contribution of the front-wheel drive is safety, with a secondary consideration of comfort and possibly a third in economy. Three factors make possible the added safety of the front-wheel drive: its unusual lowness of design, its lack of unsprung weight and its "pulling traction." About two years ago two prominent figures in the American motor industry became associated in the production of a front-wheel drive car. After eighteen months of experiment, day and night, a new front-wheel drive car was announced.

Probably the most noticeable feature of the new car is the closeness with which it hugs the ground. The Phaeton-sedan, for instance, is only 61 inches high at the peak point, but even with this low construction there are fully 38 inches of head room. The average rear-drive sedan stands 70 to 73 inches with the same amount of head room. The hood is 46 inches in length, giving the car an unusually fleet and powerful appearance. The front fenders have

an overall length of 80 inches, and are the longest used in any production car. They are of the one-piece type and their long, sweeping lines again add to the fleet appearance of the machine. The radiator is of the " V " type, with the top line of the hood practically parallel with the ground. The body itself is stream lined throughout, with the rear seat on the same level as the front.

From a mechanical and engineering standpoint the front axle and method of drive are of chief interest. With the new front drive, the engine, the transmission, the drive shaft, the differential and the driving axle become a single power unit, thus adding to the efficiency of the car. The front axle is three-quarter floating, and consists of a latitudinally bowed tubular member joining the steering knuckles. The propeller shafts are entirely separate from this, entering only at the ends where the steering knuckles are attached. The transmission and differential are all located directly at the back of the front axle and are mounted on the frame of the car, becoming sprung weight. Universal joints are provided in the propeller shafts, the two inner ones being of the Universal Products type, and the two outer ones of a special constant velocity type. Hitherto designers of front-drive cars have been hampered by their inability to obtain a universal joint which would give constant velocity to the front wheels when making a turn, but by the new type universal joint, the turning radius of the car has been reduced to 21 feet, or less than that of any rear-drive car of the same wheel-base. The car described is driven by an eight cylinder Lycoming motor, 125 horse-power, which has been developed specially for this model.

Advantages of " Ethyl."

Early investigations of the cause of " knocking " in motor engines led to the discovery that certain chemicals, added to a fuel in small amounts, were capable of eliminating this " knock," and prolonged research has disclosed the fact that the most effective " anti-knock " is the red fuel called tetraethyl lead. The developments of the few years which have elapsed since petrol containing tetraethyl lead was first used commercially are outlined in an article by Mr. Graham Edgar, under the title " Defeating the Gasoline Knock."

On 1st February, 1923, he writes, a new gasoline, to which the name " Ethyl " had been given, was placed on sale at Dayton, Ohio. Motorists who tried the new product, largely perhaps out of curiosity, little knew that the eyes of many engineers were focussed upon this petrol or guessed that the new gasoline was destined to influence profoundly both the oil refiner and the automobile engineer. The new product was a success, and one by one many of the leading oil companies added tetraethyl lead to their own gasoline ; but the rapid increase in the use of this preparation is only part of the motorist's debt to the investigators who discovered tetraethyl lead.

Increased Efficiency.

The discovery of this substance focussed the attention of the automobile engineer and the oil refiner upon the " knock " and its removal, and opened the way for increasing the efficiency of the motor-car engine. It has long been known that the most important factor in limiting the efficiency of the engine is its compression ratio, that is, the ratio of the total volume of the cylinder and cylinder head when the piston is at the bottom of its stroke to the volume when the piston is at the top of its stroke. The higher this ratio, the more power may be developed when a given amount of fuel is to be burned. The knocking tendency of internal combustion engines limits the extent to which the compression ratio can be raised when using ordinary gasoline, for the " knock " brings with it a drop in power. Tetraethyl lead added to gasoline limits " knocking " and permits a higher compression ratio to be employed than could be used without it.

Mr. F. D. McHugh, another writer, contributes an interesting survey of the developments and changes in design of American cars during the past few years. In general, improvements have been limited to such details as spring shackles, carburetters, rumble seat doors, and the more general adoption of four-wheel brakes, of safety glass and of other safety features. Several models, however, have greatly increased in engine power, and many cars have been equipped with newly developed devices which add much to engine capacity, to riding comfort and to ease of driving.

One leading American manufacturer has recently developed a new carburetter which is thought to have many advantages in smoothness of operation, acceleration, safety, quietness, economy and ease of starting. Steel-backed bearings and several other features found to be of advantage in building aeroplane models are incorporated in the engines. The pistons are automatically lubricated when the choke rod of the motor is pulled out, an arrangement which pumps oil into the cylinder walls at the time when it is most needed. An eight cylinder model recently announced by another maker is a new twin-ignition car which is claimed to be the first of its kind in the world.

Problems of Ancient Glassware.

By George W. Morey, Ph.D.

On the mechanical side, the manufacture of glass has developed from a crude to a highly-technical process, but the constituents have remained essentially unchanged for over three thousand years. New American research throws light on this curious fact.

AMONG those relics which are valuable as affording an insight into the stage of development of the arts and sciences in past civilizations, none are more interesting in themselves and of greater value in reconstructing the past than those made of glass. Such objects are found in excavations of the oldest cities, and archaeological research has not yet been able to fix the beginning of the manufacture of glass. Rather, the progress of archaeological science continues to push farther back into antiquity the beginning of glass-manufacture ; and the progress of chemical science, in furnishing an answer to what glass is, and the unique character of this artificial material, emphasizes the importance of the discovery of its composition, and the considerable amount of accumulated observation and experience which it represents.

An Early Legend.

Most people are familiar with Pliny's story of the discovery of glass, and, because of it, until recent years the achievement was credited to the Phoenicians. The story is that mariners, driven out of their course by storm, landed in Palestine, at the mouth of the river Belus, and prepared to cook some food. Wood was available, but no stones to make a fireplace. Accordingly, they took from their cargo blocks of natron, an impure sodium carbonate which was an important article of commerce. The heat of the fire melted the natron, which dissolved the sand of the river bed and formed a transparent glassy mass, a discovery which these shrewd merchants soon turned to profitable account. It is a plausible tale, but modern researches have made it certain that it is apocryphal, for glass-making has been found to antedate the Phoenicians by many centuries.

Egypt has often been claimed to be the birthplace of the glass-industry, and the oldest pieces of accurately dated glassware are Egyptian. The earliest known piece of glass bearing a date is a large ball-bead with the cartouche of Amenhotep (1551-1527 B.C.) now in the Ashmolean Museum at Oxford, but specimens from the middle period of the dynasty are numerous. Sir Flinders Petrie says : "A few pieces of glass had been discovered which could be attributed with fair accuracy to the First Dynasty of Egypt, that is, 5500 B.C., but following this nothing more was found until a few more pieces came to light which could be dated to about 3500 B.C." He comments on the rapid increase in the amount of Egyptian glass subsequent to 1500 B.C., and believes that the actual production of glass in Egypt began at that time. Sculptural records of the same period are found showing Syrian workmen being brought into Egypt, carrying with them vases of glass or metal which they had manufactured. The Syrians were far ahead of the Egyptians up to this period in the matter of art and industry, and the glassware imported into Egypt prior to 1500 B.C. probably was of Syrian origin.

There is much evidence showing that it is to Asia Minor, probably in the northern region of Mesopotamia, possibly still farther north, that we must look for the beginning of glass-manufacture. Glass beads are plentiful in the excavations of a cemetery of the Third Dynasty of Ur (2450 B.C.), and further work in this most interesting region may throw a flood of light on the history of glass-manufacture.

Discoveries at Nineveh.

Explorations at Nineveh have yielded much material of value to the student of archaeology, but to the historian of science nothing has surpassed in interest the translation of certain cuneiform tablets of the time of Assurbanipal (668-626 B.C.), some of which bear the colophon of "The Library of the Temple of Nabu." The translation is by R. Campbell Thompson, and represents a noteworthy contribution to science.* The tablets are factory records, and give not only the Assyrian names for various kinds of glass, but also directions and formulae for their manufacture.

Early glass-making differed in its chief purpose from glass-making of to-day. The first glassware was in imitation of precious stones, and the earliest glass objects are beads, usually of coloured glass. Later glass was used for hollow vessels, which were not blown but moulded, probably by applying the

*See "On the Chemistry of the Ancient Assyrians." Luzac & Co. London, 1925.

glass in a plastic condition to a sand core, which was afterwards removed. Some of the objects made in this manner were of intricate design, with patterns built up in the glass, inlaid in a mosaic fashion, and the dress of a figured subject consisted of as many as 100 to 150 squares of coloured glass joined together, the rod of glass being drawn out until threads of it were no more than a thousandth of an inch thick.

From Egypt to Rome.

Coloured and decorative glassware flourished in the Ptolemaic period, and the glass houses of Alexandria were long famous. From Egypt the industry was carried to Rome at about the beginning of the Christian era, and after a century or so became a flourishing industry. In the time of Nero clear drinking-cups and goblets made of glass were made by Roman citizens, and were much prized. In A.D. 220 Alexander Severus laid a tax on the glass manufacturers of Rome, who existed in such numbers that a principal portion of the city was assigned to them. The Portland vase, whose recent attempted auction brought it again into public notice, belonged to this period of Roman art, probably dating from about A.D. 150. The first mention of the use of glass for windows is noted by Lactantius, at the close of the third century. From Rome the art spread in various directions; to Constantinople, where it flourished for centuries; and to Venice, where, for the first time, production was on such a scale that the lowered price altered glass from a luxury into a necessity. The technical excellence of the Venetian glassware gives evidence of the highest degree of craftsmanship, while the beauty of its design has never been surpassed.

The mechanical processes of glass-manufacture have developed from the early crude, superstition-ridden, secret art to a scientifically controlled large scale manufacturing enterprise, and it is pertinent to inquire if the progress in chemical composition has been on a corresponding scale. Here we encounter a curious fact. Most glassware, to-day and from the beginning, is composed essentially of three constituents, soda, lime and silica. Moreover, in general the proportions of these three constituents are the same to-day as they were in 1500 B.C. This is well shown by the analyses in the table below, which includes only the major constituents.

It will be seen that, after all, the composition of glassware has not changed much in four thousand years. To be sure, there are to-day many special glasses, such as Pyrex and certain glasses for optical purposes, which are essentially new and different, but these are but a fraction of the total glass manufactured. The great bulk of glass to-day has the same composition as ancient glassware. What is the reason for this apparent lack of enterprise along chemical lines, when progress has been so marked along mechanical lines?

First consider the nature of the material. Glass is characterized by such peculiar properties that it is almost a fourth state of matter. Most materials and mixtures, when cooled after melting, change from the obviously liquid state, freezing into opaque aggregates of crystals. To form a glass, the molten material must cool without undergoing any such transformation; must merely get stiffer and stiffer, passing by imperceptible stages from a fluid molten mass to hard brittle glass, remaining homogeneous and transparent throughout the process. At no stage in the cooling is there a sudden change in properties, such as is found on cooling all other molten materials. When a molten metal or salt is cooled through its freezing point, it changes suddenly from an obviously liquid condition to an obviously solid or crystalline condition. Both the marked change in properties, and the suddenness with which the change takes place, are characteristic of the freezing of all substances other than glass, and are entirely lacking in glass. But this is not surprising, for these sudden changes are the marks of a transformation from a liquid to a crystalline solid, and glass remains a liquid throughout the cooling. All glasses are liquids; and glass may best be defined as a liquid whose rigidity is great enough to enable it to be put

Some Analyses of Ancient and Modern Glass.*

		1.	2.	3.	4.	5.
Silica	SiO_2	67.82	63.86	65.95	67.74	69.42
Lime (and Magnesia)	$CaO+MgO$	6.33	12.04	8.26	7.66	9.19
Soda (and Potash)	Na_2O+K_2O	16.05	23.46	21.26	21.70	18.22
Alumina (and Iron)	$Al_2O_3+Fe_2O_3$	5.44	1.32	2.77	4.48	2.71

*1. Dark blue opaque glass from the tombs at Thebes, 1500 B.C.
2. Transparent glass, Tell el Amara, 1400 B.C.
3. Egyptian glass, Island of Elephantine, 200-100 B.C.
4. Roman glass, Mainz, second century A.D.
5. Modern bottle glass.

DECORATED GLASS VASES AND KOHL TUBE OF THE EGYPTIAN XVIII-XX DYNASTY.

to certain useful purposes. A glass can only be obtained by cooling a melt through its natural freezing point in such a manner that the transformation from liquid to crystalline solid does not take place. A glass has a natural freezing point. Common window glass can be induced to freeze by proper heat treatment within a narrow temperature range, above a bright red heat. Then, however, it is no longer glass but a very different white opaque mass, which must be remelted to transform it again into glass.

Of all the possible mixtures of all the materials known to man, only three types of mixtures are characterized by this tendency to pass through their natural freezing points unchanged, persisting as rigid liquids at ordinary temperatures. These three types are characterized by the presence of phosphates, borates, or silicates, and the silicates are the glass-formers *par excellence.* Apart from other considerations, only the silicates possess the essential quality of remaining unaltered by water and atmospheric agencies. Hence of all the possible combinations of matter, only those combinations high in silica—that is, which contain a large proportion of the composition characterizing ordinary sand—are possible for glass-manufacture. But of the silicates, the combinations that are suitable for glass-making are strictly limited. Ordinary rocks are silicates, and the common rocks can be melted in the glass-furnace, but the chemical ingredients of none of them are such as to be possible for glass-making. They either freeze and become opaque on cooling, or are so thick and viscous that they cannot be properly worked at the highest temperatures.

As a practical matter, then, glass ingredients are limited to silica, lime and alkali ; and glassware from the earliest times has been made from these materials. But even here the proportions must be kept within narrow limits. Sand, lime and soda may be mixed in any proportion, but only a restricted composition range will give a glass. That such a narrow composition range exists was the discovery which marked the beginning of glass manufacture ; and to keep the secret of the proper proportions of the various ingredients of glassware has been the prime motive of the secrecy and mysticism within which glass-manufacture has been shrouded from the earliest times to the past decade, and from the influence of which the industry has not yet freed itself. The reason for this restricted composition range is to be found in the physico-chemical relationships of the ingredients, and once these relationships are known, long-cherished glass formulae become obvious deductions from them. These physico-chemical relationships have only recently been discovered by workers in the Geophysical Laboratory of the Carnegie Institution of Washington.

The secret is simple, once it has been found out. The various ingredients of glass, especially soda (Na_2O), lime (CaO) and silica (SiO_2), *i.e.*, common sand, combine with one another in several different proportions to form various compound substances, each of which is an essentially new and novel substance.

These various mixtures all melt at different temperatures, and possess in varying degree that property which is the prime necessity in glass-making: the tendency to pass from the thin molten condition to the hard, rigid condition without altering to an opaque mass. Now of all the various compounds formed, there is one which far surpasses all others in this tendency, possibly because of its complex composition, represented by its formula $Na_2O.\ 3CaO.\ 6SiO_2$. Moreover, mixtures from which this compound should separate, and from which it can be made to separate by appropriate coddling, are characterized by a lower melting-point than any other mixtures of the ingredients.

The result is that by the time these mixtures have reached their freezing temperature they are so stiff and viscous that the molecular change or movement which causes the glass to become opaque can hardly take place, and then very slowly. So a mixture of this lowest melting composition is the ideal glass; and all glasses are of this composition, or near to it. As long as a glass is within this critical composition range it can be melted, worked into shape by rolling or blowing, reheated and annealed without becoming opaque. But depart in any direction, and failure results. Add too much or too little silica, and the melting temperature rises, the compounds that tend to separate are no longer the sluggish $Na_2O.\ 3CaO.\ 6SiO_2$ but more individualistic ones, which do separate, and the glass becomes opaque and worthless. Too much lime, and the glass becomes opaque; too little lime, and it is so susceptible to atmospheric agencies, especially water, that it is worthless. The same is true of the glass containing too little silica; too little of either lime or silica means too much soda, and the glass is not durable.

A Unique Material.

Thus we see that glass is not a material of haphazard composition. It is unique in the proportion of its ingredients; and these ingredients are strictly limited in character. To be sure, no ancient glass, and no glass to-day, is a pure soda-lime-silica glass; impurities present in the raw materials added other ingredients, but only in secondary amounts. So long as the mixture was essentially soda, lime and silica, a glass resulted; if the impurities became preponderant, failure alone could result. There was, however, some leeway, both in the amount of impurities, and in the proportion of the major ingredients. The better glasses of to-day are so proportioned that the soda is kept as low as possible, to make the glass more resistant to water, although it is thereby rendered harder to melt. But in the primitive glass-manufacture, the low-melting feature was more important, and as a consequence the alkali content of the older glasses was higher than is considered good practice to-day. In fact, glass which has been preserved in Egyptian tombs since 1500 B.C. would be rejected by the critical user of to-day as lacking in durability.

Nevertheless, glass, however crude, is a unique artificial material, whose discovery must have been one of man's earliest conquests of his environment. That the secret of glass was brought from that mysterious region north of Mesopotamia from which civilization itself emerged, places the beginning of this mighty industry in the very cradle of the human race, and points to a high mental capacity in the earliest peoples whose relics afford us an insight into the past.

Bird Life in the Arctic.

OBSERVATIONS made in the Canadian Arctic during 1929 by Mr. P. A. Taverner, ornithologist of the National Museum, indicate that the eastern coast of the archipelago is not particularly rich in bird life. It is evident that the great migrational bird highway runs through the territory adjacent to western Baffin Island rather than along the eastern coast, and this is borne out by Mr. J. D. Soper's discoveries along the west side of Baffin Island. Sea-birds of certain species are distributed in enormous numbers over the open waters of Baffin Bay and the larger sounds to the west. Fulmars were noted throughout the greater part of the voyage, though none were observed during the trip through Hudson Strait. In the more northerly parts of Baffin Bay dovekies occurred in almost incredible numbers, nesting apparently only on the north Greenland coast. Black or Mandt's guillemots in these northern latitudes show a tendency to congregate in certain favoured localities, although miles of suitable coast were followed without seeing this species. Glaucus and kittiwake gulls are fairly common over sea and land, and seem to be the most general breeding gull. A few gulls of the herring type were seen, but no definite evidence of breeding in these areas was obtained. A few ivory gulls at Dundas Harbour were the only ones of the species noted. With the exception of south-western Bylot Island, the land of the eastern islands is high and bold and none of it is suitable for waders. Very few were seen until the lowlands at the mouth of Hudson Bay were reached, when a marked change in bird life conditions occurred. Two Hudsonian curlews were collected at Chesterfield Inlet, where the natives declare they are so rare that some had never seen the species before.

Book Reviews.

Introduction to the History of Science. By GEORGE SARTON. Vol. I. (Balliere, Tindall & Cox. 45*s*.).

A History of Science. By WILLIAM CECIL DAMPIER DAMPIER-WHETHAM, M.A., F.R.S. (Cambridge University Press. 18*s*.).

Two Thousand Years of Science. By R. J. HARVEY-GIBSON, C.B.E., D.Sc., F.R.S.E. (A. & C. Black. 12*s*.).

Students of science owe a very great debt to Mr. George Sarton, who is an Associate of the Carnegie Institution of Washington. We are concerned at the moment only with the first volume which deals with the progress of science from Homer to Omar Khayyam. There are several volumes to come, and we look forward with the greatest pleasure to the next instalment of this comprehensive study. The present volume is a monumental work of scholarship and sympathetic erudition. Its plan is most helpful and amply fulfils its promise, not only to provide an invaluable work of reference, but also as a panoramic guide of considerable literary charm.

There are twenty-four chapters covering a period from the ninth century B.C. to A.D. 1100. For the most part each chapter comprehends half a century, and after a general survey of the scientific progress achieved, in the latter part deals particularly with outstanding figures of importance. There is also a remarkably complete bibliography of the relevant literature.

Not the least valuable part of the book lies in the scholarly manner in which the development of knowledge is shown against the contemporary religious background. The result of this treatment is that we are provided with a remarkable study of the interaction of spiritual and intellectual evolution. The author has cleverly preserved definite continuity of narrative through a period dissociated by geographical, philosophical and social boundaries. As a work of reference the volume is indispensable to the scientific man, but it has a wider appeal than this—it is a book to read and enjoy.

It is a matter for extreme satisfaction that general interest in scientific history is so active at the present time, and, indeed, it is difficult to imagine a more enthralling study. Mr. Dampier-Whetham's book is a concise and most readable volume. The book is not large—some five hundred pages—but it is impossible to think of any important phase of scientific development which has been omitted and the crucial epochs are dealt with in considerable detail. Science in the Ancient World, The Renaissance, The Newtonian Epoch, Nineteenth Century Physics, The New Era in Physics, are some of the chapter headings and convey a rough idea of the scope of the work.

It is always difficult to decide how far a scientific history can hold the attention of the non-professional reader: Mr. Dampier-Whetham presents the subject very largely from the philosophic point of view, which has the great advantage that the general student is able to appreciate this somewhat specialized branch of knowledge in its relation to the general scheme of things. The present day tendency to over-specialization in science has resulted in remarkable advances in knowledge, but at the same time it is not without danger. It is essential, therefore, that scientific men—particularly young men—should cultivate a due perspective in their outlook, in other words, that they should realize the essential symbolism of science. From this point of view there is no more salutary study for the scientist than the history of science, and therefore authoritative and scholarly books such as the one under notice are doubly welcome in this age of intensive study. The general reader will enjoy this delightfully written account of the science of early days and a description of modern scientific ideas divested of their usual mathematical expression. He will, moreover, appreciate the *relative* value of scientific progress in the history of civilization.

The third book under notice is a scientific history of a different type. It is an elementary account (written for the lay reader and not for the expert) of the discovery and development of well-known scientific phenomena and laws. The author (who died before the book was published) was Emeritus Professor of Botany at Liverpool University, and undertook the work because he had been asked to recommend a book that would give the reader "a general sketch of the growth of science from early times down to the present day." Dr. Harvey-Gibson amply fulfilled this requirement, and his work will supply a very general need. It is comprehensive, accurate, and very readable. It is a straightforward summary of the facts enlivened by many an interesting anecdote, and happily without any of the lamentable "humour" which some authors of "popular" scientific books appear to regard as of greater importance than the phenomena they purport to describe. Dr. Gibson, on the other hand, paid his potential readers the compliment of regarding them as sane reasonable people, earnestly desirous of learning something of scientific development.

The author was a distinguished botanist, consequently the chapters on biology and biological chemistry have a particular interest, nevertheless other branches of science receive full and careful attention. In particular the pages dealing with Relativity deserve special notice; they contain a remarkably clear and interesting description of the theory easily appreciable by the non-mathematical reader. It is obvious that the author enjoyed writing this book and spared no effort to explain difficult scientific matters in a truly informative manner. It is one of the best popular dissertations on general science that we have seen.

V. E. PULLIN.

The New Nature Study. By F. J. WRIGHT. (Thornton Butterworth. 5*s*.).

The study of wild nature is one of the most pleasant of hobbies, but the ordinary naturalist, who is neither a specialist nor a Gilbert White, is apt to feel the lack of a definite objective. Observation, with no definite purpose in view, is dull, and mere aimless collecting, which most of us have indulged in while young, soon palls and should be discouraged because of the danger of extinction of rare animals and plants. The author of this interesting little book points out that there is one branch of nature study at least in which every naturalist can assist, with the full confidence that his observations will be not only of growing interest to himself, but of real value to others. That subject is phenology, the study of the occurrence of certain natural events, such as the dates of flowering of various plants, the arrival of migrant birds and the first appearance of insects.

Organisms in a state of nature, and especially plants, are highly susceptible to weather conditions, and the date on which a specified plant reaches a stage such as flowering is determined by the sum total of the weather conditions, both at the time and during the preceding months. Plants and animals can, in fact, be regarded as meteorological instruments, more comprehensive if less exact than thermometers and sunshine recorders,

and in many ways of more practical value. Isolated observations are of little use, but when the results of a number of observations, made in all parts of the country on a uniform plan, are combined in charts, some highly interesting generalizations can be made. Some parts of the country are more forward than other parts; some years are early, others are late, and the variations can be compared with weather conditions. Laws emerge, which are equally applicable to crops, and the phenological observer, reporting each year to the Phenological Committee of the Royal Meteorological Society, is therefore assisting agricultural research.

Plants, birds, and insects employed for the scheme are common and easily known, but if any one has difficulty in recognizing them, this book describes them simply and clearly, and gives interesting particulars of their habits and habitat. Then follows a description of what to look for in the different seasons, practical hints on nature study in the field, with suggestions for definite lines of research, and some notes on nature photography. The keynote of the whole is purposeful observation of the live subject instead of killing it out of hand, an outlook which is sufficiently novel, in a popular book, to justify the title.

C. E. P. BROOKS.

Then I Saw the Congo. By GRACE FLANDRAU. With Maps and Illustrations. (Harrap & Co. 12*s.* 6*d.*).

Trailing the Giant Panda. By THEODORE and KERMIT ROOSEVELT. (Charles Scribner's Sons. 16*s.*).

Unlike most explorers, Miss Grace Flandrau was not concerned with the discovery of new territory; the challenge of Africa lay for her in the fact that, while the rest of the world has been changing its clothes, ideas and religions so continuously for several thousand years, she believed there were certain peoples in the equatorial forests of Africa who went their prehistoric ways unchanged. Miss Flandrau wanted to find them and to photograph them. The description of her trip across Africa, along the Equator from the west coast through the Belgian Congo and Tanganyika to the Indian Ocean, the long tramp through the pigmy forests, shooting the rapids in dug-out canoes, her meeting with cannibals and wild tribes, and her visit to the Mangbetus, the most cultured natives of the Congo, form a gripping story. She describes the famous West African slave coast, where once "the tall-masted slavers rocked at anchor, waiting, while down these rivers of anguish to the sea came captives in millions, led by the first Christian music they had ever heard—the singing of whips, the rattle of chains and the weeping of mothers." Africa, the sombre, the tragic, the humorous, the incalculable continent, is vividly portrayed. The book contains thirty-one illustrations, which are reproduced from films taken during the expedition, in addition to maps showing the journey across Africa and the journey in the Ituri Forest.

Miss Flandrau's pilgrimage was inspired by a desire to see new people; Theodore and Kermit Roosevelt went in search of a rare animal. The books, therefore, differ somewhat in detail, but both are fascinating stories of adventure in strange lands, and each is equally well written. The Roosevelts have recently returned from an expedition to the Yunnan and Szechuan provinces of China, where, in the interests of the Field Museum of Chicago, they spent six months trailing the Giant Panda. Previously, the panda had only been known by the fact that a few incomplete skins had been traded from time to time from the natives. Since 1869, when the first of these skins was brought to Europe, repeated attempts to secure a panda had failed. The Roosevelts set out to secure a specimen and, after hunting hard and long for many weeks, their efforts were at last rewarded while they were trailing in the Yelhi district. How the chase ended in the capture of a "fine old male," the first that has ever been killed in the region of Yelhi, is graphically described. Added interest is lent to the story by the fact that the authors have adopted the system of each contributing alternate chapters, so that a very complete account of the expedition is given.

The Problem of Time. By J. ALEXANDER GUNN. (Allen and Unwin. 16*s.*).

Time is as old as the hills, but as a problem in philosophy it is largely modern. It was the great discoveries of the eighteenth and nineteenth centuries which led philosophers to take time seriously and to realize how essential an ingredient it is in the nature of things. Three names testify how important it is to understand the nature of time. Professor Bergson regards time as the greatest problem of philosophy and Professor Bosanquet as the central crux of philosophy. Professor Eddington believes it to be the key-position in any attempt to bridge the domain of experience belonging to the spiritual and physical sides of our nature. To try to understand the nature of time is, therefore, the obvious duty of the present day philosopher. It is accepted that although psychology and physics can both contribute enormously to the discussion, the problem is a metaphysical one. Unfortunately, as Dean Inge has pointed out, it is the hardest problem in metaphysics.

Professor Alexander Gunn has included in this book nearly everything of distinctive quality that has been said about time since the days of the Greeks. He has shown wide reading and brought to his task great powers of compilation in this attempt to give an informed and critical discussion of the subject. Unfortunately, the book is not well put together. It is altogether too long. In many places it is discursive. There is a good deal of repetition and occasionally in an endeavour to be comprehensive the author treats us to bad views as well as to good ones, views, in fact, which if accepted would make the best that is known on the subject absurd. For example, in the final chapter when the author is summing up and the reader, doubtless, is all attention, the views of two men who claim that prophetic dreams have occurred are interjected and criticized at some length, whereas the right criticism is to ignore. Prophetic dreams are most simply explained as due to coincidence and not to anything in the structure of the external world.

But the book has many merits. It sets before the reader the best that is known on a subject which is of great interest to the ordinary person no less than to the philosopher. It does not profess to solve the problem of time, but it shows how extraordinarily interesting the problem is. Here, indeed, is a subject which a reader might well take up as an intellectual hobby, because it touches life as well as philosophy, natural science and psychology at so many points.

Is time absolute or relative? How far, if at all, does our awareness of time, or our measurement of time, give a clue to its nature? What is meant by saying that time is the fourth dimension, and what evidence is there to support or disprove this rather vague description? How far is time objective? These and other questions are raised and discussed in the different chapters. The first two chapters recount the little of

importance that was said of time before the time of Isaac Newton. The third chapter deals with the views of Newton and the early moderns, of such men as Locke, Berkeley and Leibniz. The next chapter deals with time in the philosophy of Kant, perhaps the greatest man who has thought on this subject. Next follows a chapter on the physicists and the problem of time measurement; there is given an account of the theories of relativity and of simultaneity; it is concluded that measurement of time gives no clue to its nature; this remains a metaphysical problem. The next chapter, which deals with time in contemporary metaphysics, is not very illuminating. It shows us clearly what strange people contemporary metaphysicians seem to be compared with Kant or with the physicists. In the final chapter the author sums up very carefully. An appendix describes the experiment of Michelson and Morley. A bibliography is given.

A. S. RUSSELL.

Discoveries and Inventions of the Twentieth Century. By EDWARD CRESSY. Third edition. (Routledge. 12*s.* 6*d.*).

The Book of Electrical Wonders. By ELLISON HAWKS. (Harrap. 7*s.* 6*d.*).

Those who wish to have a non-technical account of the great scientific discoveries of recent years will welcome the recent publication of the third edition of Mr. Edward Cressy's book. Progress of late years has been so rapid that it has been impossible to include in a single volume an account of all the discoveries of the twentieth century. The author has selected certain fields of enterprise, therefore, and has described the chief features in their development during the last twenty-five years. The revival of water power, modern steam, gas, oil and petrol engines, electric lighting and heating, soil, crops, modern chemistry, railways, motor-cars, ships, airplanes, photography and radium are among the varied subjects with which Mr. Cressy deals. The book is written in simple language, and, where the author has touched on technical detail, the descriptions are lucid and the explanations are clear. The third edition has been considerably enlarged and the number of illustrations has been increased. Reference has been made to such recent discoveries as the screened-grid valve, photo-telegraphy, the slotted wing for airplanes and the growth of the artificial silk industry.

The electrical discoveries which Mr. Cressy describes are dealt with more fully, together with many other inventions, by Mr. Ellison Hawks. Many of the everyday wonders made possible by electricity are outlined, and the author has shown discrimination in describing only those which are likely to be of interest to the general reader. The book opens with a description of how electricity is produced, and this is followed by a chapter on power stations and hydro-electric schemes. Electric light is then dealt with, including the discovery of the arc and the invention of the incandescent electric lamp. From a discussion on the amazing temperatures obtained from electricity the author passes to a description of the modern telephone exchange. The story of X-rays, and their industrial and scientific application is then told, and a subsequent chapter deals with the electric transmission of pictures. The book concludes with an outline of the recent discovery of television. Mr. Ellison Hawks tells an absorbing story of the amazing developments of electricity in recent years, and his remarks are illustrated with a pleasing number of informative diagrams and photographs.

Above and Beyond Palestine. By C. E. HUGHES. (Ernest Benn. 10*s.* 6*d.*).

This book is in a class by itself among records of the war, and as such is decidedly a discovery. The sub-title, "An account of the work of the East Indies and Egypt Seaplane Squadron" 1916-1918, describes its historical purpose. The author was Intelligence Officer to the Squadron, and has effectively illustrated much of the narrative with pen-and-ink sketches.

Not long ago Mr. Arnold Bennett labelled 1929 the year of the war book. Most of these writings are by Germans, and almost all belong to the Realist school—which is another way of saying that the authors make no bones about horrors and misery, which are often intentionally stressed. They deal mainly with the Western Front, where the fighting was fiercest, and their memories are probably common to the majority of sensitive minds. At the same time, to large numbers of the civilian army who had never in their lives been abroad before, the war was something of an adventure. And conditions in the Near East were not lacking in romance. As approaching the subject from this angle, Mr. Hughes' book supplies a point of view that is essential to a full picture of the war. Its pages were written shortly before the Armistice, and are printed with only slight modifications. The author would be the last to deny the tragedy of fighting, but to suggest that every soldier was continually conscious of it is frankly one-sided. "Our war-time mental attitude towards the enemy is," he hopes, "a thing of the past, but the fact that circumstances compelled us to adopt it has an abiding and an increasing interest."

The air operations in Palestine were at first directed against the railway which the Turks were constructing in connexion with their Syrian and Egyptian campaigns. Bombing raids were made by seaplane from the carrier ships which patrolled the coasts. Not all the flights were successful, but the line was repeatedly attacked and damaged at its vital points. One of the longest flights achieved was to Damascus. Possibly the machine was mistaken for a friendly one, since a flying school was about to be established in the locality, but the mistake was quickly discovered, and five or six guns opened fire. The shells flew wide, however, and in another minute or two the seaplane was hovering above one of the oldest cities in the world. Here Mr. Hughes gives a vivid picture of "the Pearl set in Emeralds," as the Arabs call it, though from the air it had more the appearance of many pearls thrown down into a heap. "And one may imagine, perhaps, that the 'Street which is called Straight' is a line drawn through the heap by the jeweller seeking with the point of his calipers for the biggest or the finest specimens of the collection, a fancy which need not be affected by the fact that part of the street is arched with corrugated iron."

But thoughts such as these were not for the pilot and observer, who were there to make as close an inspection as time allowed of trenches, camps and hangars. On the return flight to the sea, following the main road, another battalion of troops was observed. "Their faces could be seen as they gazed upwards in wonder and bewilderment, but few of them were ready with their weapons, and no damage was sustained from the very spasmodic fire they put up."

For two years the raids were continued over the borders of Palestine, sometimes with disaster to the airmen, but by constantly harassing the Turkish forces, the squadron helped to prepare the way for General Allenby. There are several thrilling

chapters in this book, but for graphic description none surpasses the account of how the "Ben-my-Chree" was sunk by Turkish gunfire.

E. D.

Enigmas: Another Book of Unexplained Facts. By LIEUT.-COMMANDER R. T. GOULD. (Philip Allan. *12s. 6d.*).

Commander Gould, the author of "Oddities," has now compiled another book of unexplained, and apparently inexplicable, facts. He has collected the details relating to a number of historical incidents and has presented the facts, wherever possible, in the form of quotations from the original sources. The mysterious cry of the Memnon statue, the story of the man who lived for a century and a half, the bells which were rung by an unseen hand while a watch was actually being kept upon them, the exact identity of the island which Columbus named San Salvador, and, finally, the much vexed question of the Martian canals, are among the enigmas with which this book deals.

Perhaps the most interesting of these cases is that of Thomas Parr, reputed to have reached the tremendous age of 152. A copper-plate engraving of Parr, published two days before his death, describes him as "the olde, old, very olde man, Thomas Parr, the sonne of John Parr, of Winnington, in the parish of Alderbury, in the county of Shropshire, who was borne in 1483 and is now living in the Strand, being aged 152 yeares and odd monethes." These facts are borne out by another authority, whose dates were based on particulars of the various leases granted to Parr in respect of a small holding which had passed to him from his father. In connexion with a life lease which Parr obtained towards the end of his career, Commander Gould retells an anecdote which appeared in a pamphlet on sale in London two days before the old man's death. Parr, for his wife's sake, wished to renew his lease for some years, to which his landlord would not consent. The old man had long been blind. So when his wife looked out of the window and saw Master Edward Porter, the son of the landlord, coming towards the house, he said to her, "I prithee, wife, lay a pin on the ground near my foot or at my right toe," which she did before the visitor entered. "After salutations between them (the story continues) the old man said, 'Wife, is that not a pin which lies at my foot?' 'Truly, husband,' quoth she, 'it is a pin indeed.' So she took up the pin, and Master Porter was half in a maze that the old man had recovered his sight again; but it was quickly found to be a witty conceit, thereby to have them suppose him more lively than he was, because he hoped to have his lease renewed for his wife's sake, as aforesaid." Apparently Parr lost his sight in 1616, so he must have been over 143 at the time of this incident.

Parr's history is made more mysterious by the fact that, in November, 1635, a complete examination of his body was made by William Harvey, the discoverer of the circulation of the blood, in the presence of several other of the King's physicians. Harvey could find no unequivocal indications of great age; in fact, by the wording of his account, the body might have been that of a man between the ages of sixty and seventy. Commander Gould considers that the story should be regarded as "not proven," but, in his opinion, it cannot be called incredible.

Space permits us to mention only one of the remaining enigmas, concerning the Bealings Bells. On 1st March, 1834, there appeared in the *Ipswich Journal* a long and remarkable letter from Major Edward Moor, F.R.S., of Great Bealings, Suffolk, in which he described how a peal of bells at his house would often be rung simultaneously and with extraordinary violence while an actual watch was being kept upon them, and when it seemed impossible that this could have been done by any human agency. For a period of fifty-four days these disturbances continued, and, despite persistent investigations by the major and members of his family, the cause was never discovered. Many of his friends advanced the theory that the whole thing was an elaborate hoax, but the major's painstaking observations showed that this interpretation was physically impossible, and the mystery of the Bealings Bells remains to be explained.

When Commander Gould decided to compile a book of historical puzzles so varied in subject as those which he describes, he set himself a difficult and laborious task. The fact that a number of original manuscripts were carefully examined is shown by the many references to what must have proved very inaccessible sources. It might be suggested that the collecting of facts relating to incidents which have not been, and are never likely to be, satisfactorily explained is rather a pointless occupation. Those who are wise enough to procure the book will be content to read its fascinating stories, and will, no doubt, find added entertainment in devising their own explanations of the mysterious incidents described. At any rate, they will agree that the author has dealt with an unusual subject in a very original and absorbing way.

Romance of the Planets. By MARY PROCTOR, F.R.A.S., F.R.Met.S. (Harper. *7s. 6d.*).

Miss Proctor has already successfully popularized the technical aspects of astronomy in so far as it concerns the sun, the moon and the comets, in three previous books which have been reviewed in these pages. This book is the fourth of the series and seeks to outline, in simple language, some of the astronomical discoveries of recent years. The preface points out that the books have no scientific pretensions, nor do they deal with "heavy celestial mechanics or troublesome mathematics. Rather do they incline to an account of the latest theories and advances in astronomical research, given in an entertaining and conversational manner."

The author certainly covers a great deal of ground, and her ability and qualifications to write on the subject are well known. The "entertaining and conversational manner," however, which starts so promisingly, is too frequently lost sight of in a tendency to wander from the point. In attempting to "popularize astronomy for the benefit of the general reader" Miss Proctor has, perhaps, erred on the side of unnecessarily long explanations. In the chapter entitled "Are Planets Inhabited?" for instance, she immediately embarks upon a lengthy explanation of our planet and its position in the solar system. Halfway through the chapter she returns to her subject by observing that nothing can certainly be known about life in other worlds; after which she describes in detail the relation of the sun to the other planets, and leaves the reader with the somewhat unsatisfactory observation that the habitability of other worlds depends absolutely upon their position with regard to the sun. If the book has one fault, then, it is in crowding too much detail into a comparatively small compass. There are a number of interesting illustrations, reproduced from photographs taken at the Lick and Lowell Observatories, some highly instructive drawings and a chart.

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